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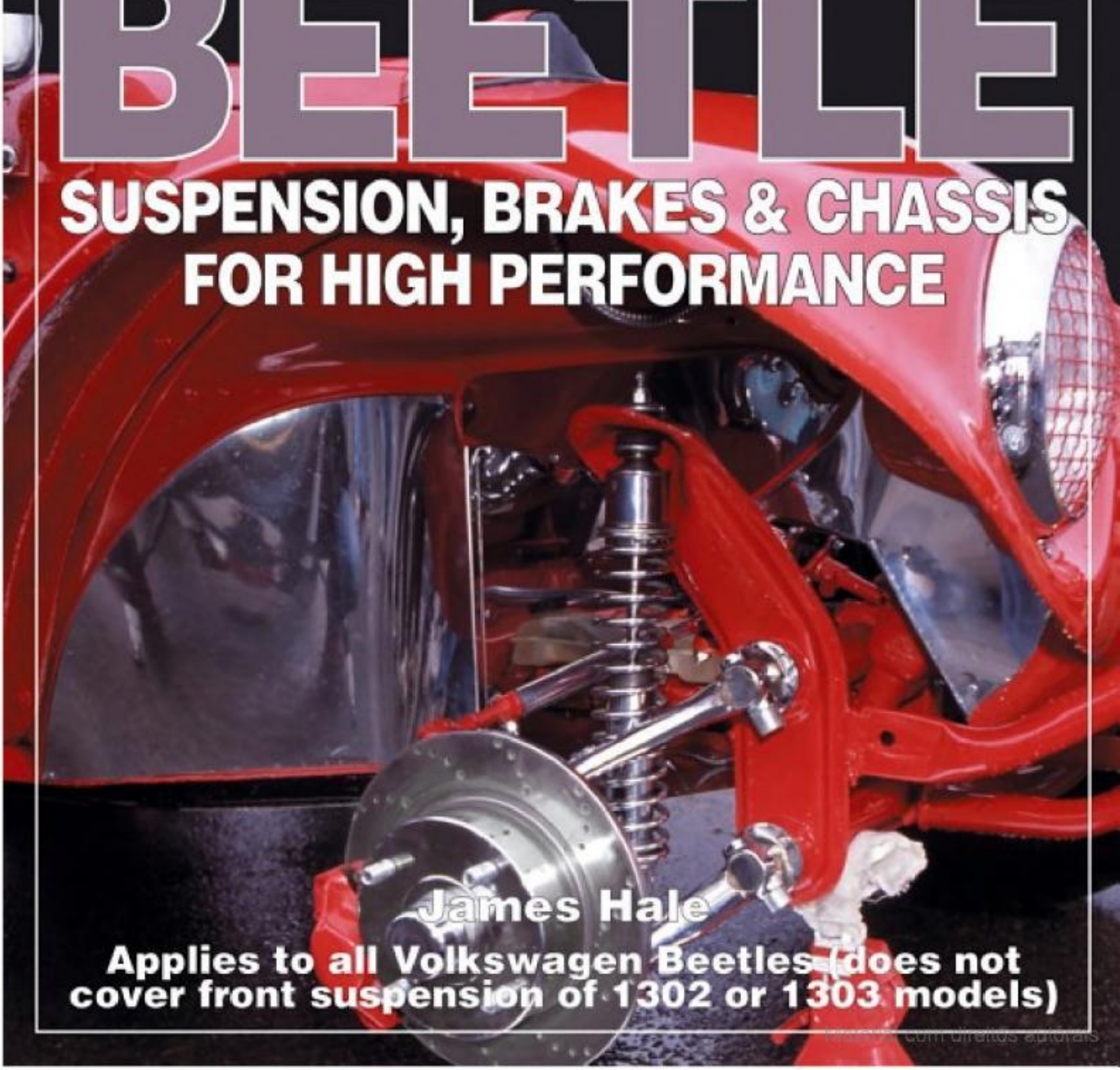
HOW TO MODIFY VOLKSWAGEN BEETLE

SUSPENSION, BRAKES & CHASSIS FOR HIGH PERFORMANCE



James Hale

Applies to all Volkswagen Beetles (does not cover front suspension of 1302 or 1303 models)

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All eBook design and code produced in-house by Veloce Publishing.

This book is dedicated to Gillian – the only person I know who can build a kit-car with a single can of WD40.

Contents

Introduction & acknowledgements

INTRODUCTION

Like that of the Coke bottle, the shape of the VW Beetle is one of the most recognisable in the world. So many millions have been made since mass production began after the Second World War that it has had a huge impact on motoring culture.

Even the least mechanically inclined person knows that the Beetle's engine is at the back, and the distinctive sound of the air-cooled, flat-four engine is unmistakable. Production of the rear-engined and air-cooled Beetle finally ended at VW's Mexican plant in June 2003 to allow manufacturing of a front-engined and water-cooled 'new' Beetle. This design had begun life in Europe in the 1990s, acknowledging but fully updating the company's landmark design

The unique design and affordable price of the Volkswagen Beetle made it the best-selling car of all time. (Courtesy Beaulieu Picture Library)

Beetle suspensions, engines and gearboxes have found their way into numerous specials and racing cars, such as the Formula Vee class. (Courtesy Robin Wager)

The Beetle has proved a serious competitor in many forms of motorsport: on the track, at trials and hill-sprints. (Courtesy John Jackson)

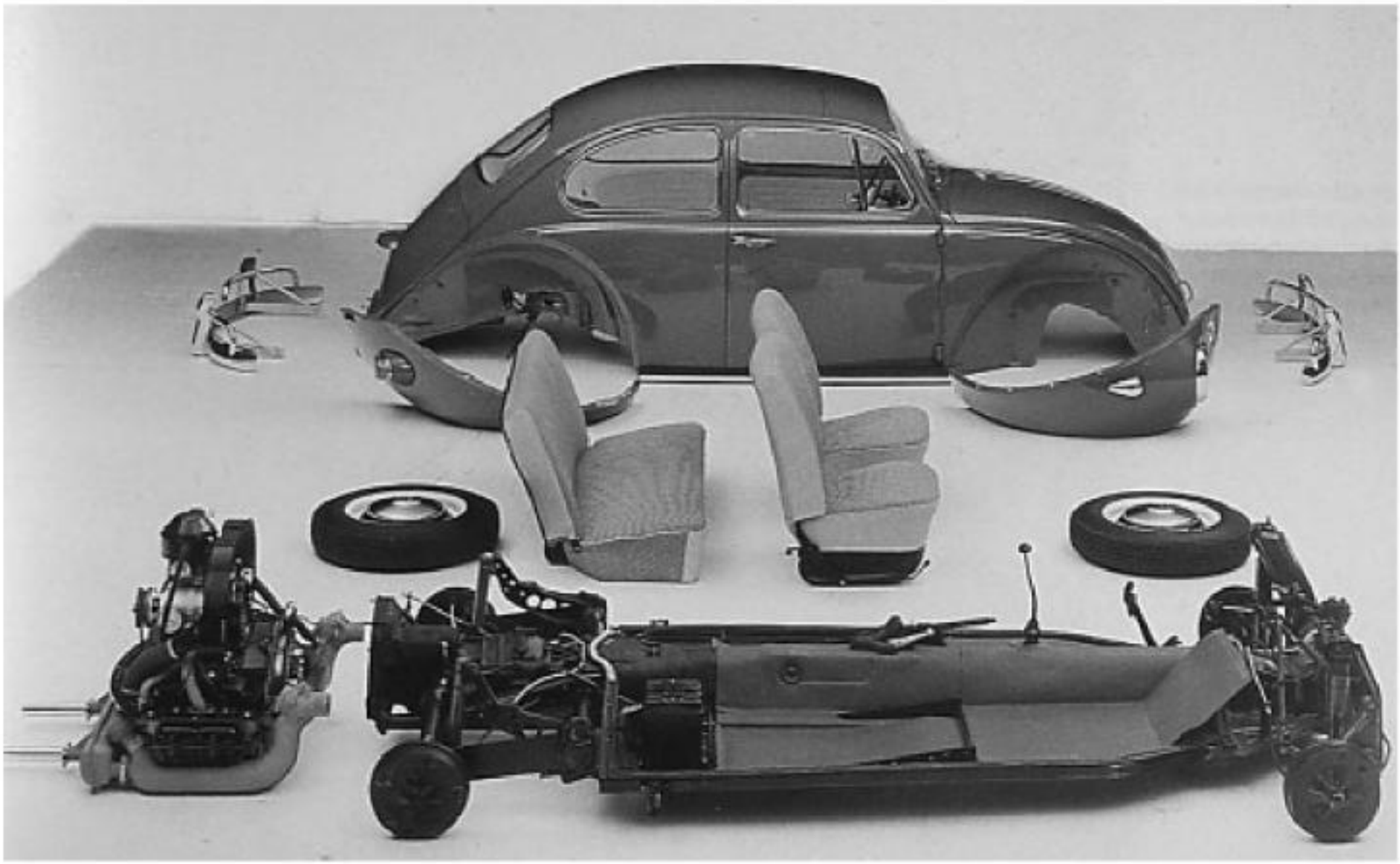
With so many examples having been built during the car's long production life, the Beetle has inevitably attracted enthusiasts the world over wishing to modify, tune, customise and generally tinker with it. Aftermarket and tuning parts suppliers have all contributed to the possibilities of enhancing the original Porsche design, and a plethora of performance parts have been made available since the 1950s, many of which are designed to maximise the power output of the humble flat-four engine. With the Beetle becoming a serious contender in motorsport as diverse as autocross, Formula Vee and drag racing, this was, perhaps, inevitable.

A profusion of books covering the specialist area of Beetle engine tuning have also been published over the years, and with such a

wealth of material available there was little point in duplicating what already exists. I have, therefore, approached this book with a different viewpoint.

My own interest in VWs began originally through a love of dune buggies, those glassfibre-bodied fun cars that were part of the youth culture of the 1960s and 1970s. Buggies were essentially made from two things: a glass-reinforced plastic bodyshell, and the rolling chassis and drivetrain of a VW Beetle upon which the new body was mounted. The Beetle lent itself perfectly to being re-bodied: the flat chassis/floorpan to which was attached the complete front and rear suspension components, gearbox and engine, remained complete even with the sedan body removed. The body was almost an optional extra, the chassis being entirely driveable without it, as witnessed in several early factory publicity photographs. This unique automotive feature induced many coachbuilders and customisers to use the Beetle rolling chassis to underpin alternative bodyshells, and thus it became the foundation for a multitude of pseudo-exotic vehicles, as well as simply the less glamorous, home-made one-offs.

The Beetle chassis provides the perfect platform on which to base glassfibre-bodied kit cars, such as the ever-popular dune buggy. (Courtesy Robin Wager)



The design allows the whole bodyshell to be completely removed from the unitary chassis and running gear, as this publicity shot shows. (Courtesy ANWB)

My involvement first with buggies and Beetles subsequently, rather than the other way around, resulted in an affinity for the VW chassis, suspension and brakes as an entity separate from whatever was attached to it. Whilst I ardently admire Beetle purists for the time and devotion they put into the restoration to original specification or customising their vehicles, I prefer to see the excellence of suspension or brake engineering on a Beetle or Beetle-based vehicle. The use of carefully chosen performance parts to make the VW go, stop or handle better is therefore closer to my heart.

I have also come to appreciate the great interchangeability of different parts available within the VW and Porsche ranges, as well as alternative component transplants available by sourcing from other marques and aftermarket suppliers. By being totally broad-minded about the opportunities this avenue presented, I have benefited by getting the best performance from my own cars at a realistic cost. Rather than viewing a vehicle as a 'complete' car, I have also tended to look at things in terms of 'individual' systems whilst working on them: this could be a brake system, an ignition system, a fuel system, a suspension system, or whatever. This has greatly helped my understanding of how these systems work. By working on individual areas of the Beetle, it also means that buying components can be spread out over a longer period of time, which helps when keeping to realistic and manageable budgets. Don't forget, though, that modification or changing of components may have a knock-on effect on other parts of the vehicle. It is important to ensure that work done in this way is not to the detriment of vehicle safety.

I wrote a series of VW-related technical articles for a leading VW magazine in the 1980s, working on the principle that others who wanted to know how to perform such modifications, and who had even basic mechanical skills, could knowledgeably and safely undertake them. It also led to the first thoughts about this book. For those Beetle enthusiasts, like myself, who wanted to find out about suspension, brake and chassis uprating and rebuilding, there appeared to be a lack of 'stand alone' information available without having to wade through the greater part of a book on VW bodywork restoration, or engine tuning.

The book you are now reading is not intended to be a definitive workshop manual – you should still consider one of these an

essential 'bible' for many jobs. Nor is it aimed at those who build high performance racing VWs or off-road vehicles, as that is an area that would take up more pages than are available in this book alone. What is here, though, is a guide to those who are hoping to get the best out of their Beetle's suspension and braking, and are happy to tackle modification or maintenance jobs that are well within the capability of the home mechanic, without the need for specialist garage equipment. Where a special tool is required (or welding equipment in the case of dune buggy floorpan shortening), this is pointed out in the text.

With the addition of aftermarket performance and Porsche parts even an early Beetle can be made to go, handle and stop like a modern car. (Courtesy Mike Ghia)

If you are new to the mechanical construction of the Beetle, it is worth reading through the text a couple of times before beginning a job or purchasing components. Always aim to work to a budget you have pre-determined, and never attempt a job if you feel it is unsuitable for your vehicle, or outside the scope of the tools you have available. Remember that your own safety and that of other road users is paramount, as you tackle jobs which will affect the driving character, handling and braking of your vehicle.

Finally, it is worth making the point that the scope of the book does not allow as much information on the 1302/03 range of Beetles fitted with the later MacPherson strut front suspension, as the earlier suspension systems. With the development of many high performance suspension and engine parts for these particular models (particularly in Europe, for street and race use), this is a separate subject for a book in its own right. The 1302/03 independent rear suspension is covered, however, as it appeared on not only the American-spec. Beetles from 1968 onwards, but also on the European semi-automatic Beetle.

I hope you will enjoy reading the book, and gain inspiration from it. Most of all, I am sure you will find something in these pages that will help you improve the handling and braking of your own Beetle. After all, driving a Beetle is one of the greatest pleasures of owning it.

Stay safe and have fun!

James Hale
Brighton, England

ACKNOWLEDGEMENTS

Despite the wealth of material already published about the VW Beetle, finding the right information, photographs and technical

details needed for this book was every bit as hard as I expected it to be.

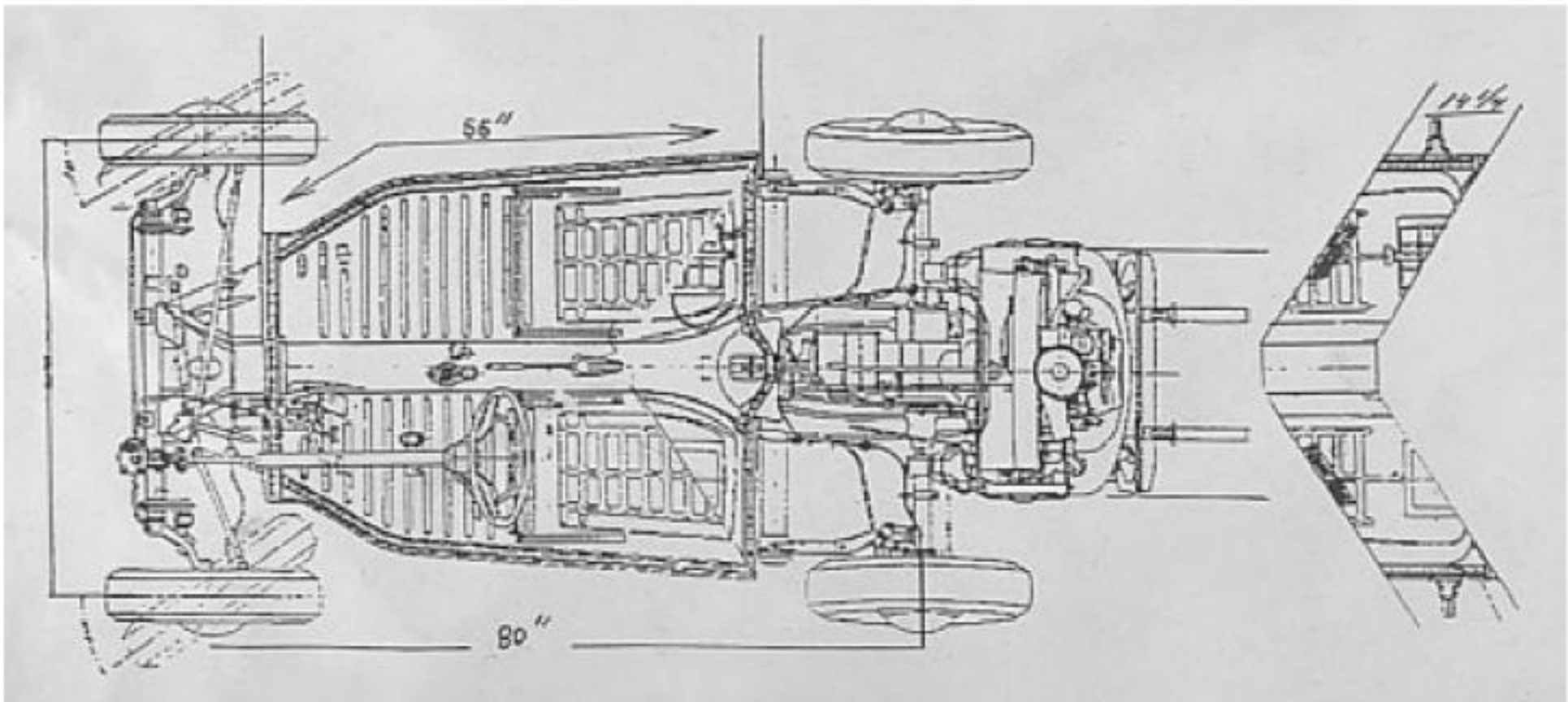
Thanks are due to the many Beetle enthusiasts, both private and professional, who saved me from the ever-present pitfalls that surround a project like this. Their photographic libraries, mechanical skills, and, most of all, their enthusiasm ensured that I not only completed the book, but totally enjoyed the experience too.

A big 'thank you' goes to the following for all their help. For photography: Mike Key, Malcolm Bobbitt, John Jackson, Robin Wager, Walter Bach, Henny Jore, Thomas Kelm at Custom & Speed Parts, Geoff Thomas at Autocavan, Johnathan Day at the Motoring Picture Library, Beaulieu, Paul Cave, editor Total VW Magazine, Ivan McCutcheon & Mike Pye at Volksworld magazine, Gene Berg Enterprises, German Car Company, Chesil Motor Company, Red 9 Design. For providing parts for photography: Howard Blakes and Justin Bishop at Wizard Roadsters, Spectra Dynamics. For helping me set up photo-shoots and general assistance: John Maher, Bernard Newbury, Mel and Sandra Baker, Peter Brunskill, Paul Burchell, and Dave Palmer at Creative Engineering.

To Mike Ghia for allowing me access to his detailed information on adapting Porsche components to the VW suspension and brake system. To Simon Glen for sharing his extensive knowledge of the VW chassis numbering system with me, and providing cutaway Beetle photos. To Neil Birkitt for reading the draft text and offering constructive suggestions, many of which I have incorporated into the final version, as well as providing photography.

And finally, to Rod Grainger at Veloce Publishing for allowing me to indulge myself with this project in the first place.

James Hale



Workshop procedures, safety & tools

WORKSHOP PROCEDURES AND SAFETY

One of the things that makes working on a project vehicle a pleasure, rather than a chore, is a clean and dry area in which to undertake the work. A garage or workshop will not only keep you and the car dry, it will also help prevent the formation of rust on any of the vehicle components, particularly if the project takes a long time to complete. Whatever area you use should have enough space to work around the car, and should at least have a bench on which to work on components, and a dry storage area for tools and parts. If you have an electrical supply and use power tools, ensure these are also kept dry and are safely stored away after use.

Before starting work on your car, think about safety first – safety is common sense but, sadly, sense isn't all that common when you are ready to rush into working on your dream car. Always disconnect the vehicle's battery strap, and remove the battery altogether if there is any possibility of a metal object falling across the terminals. Remove the fuel tank if you are using a heat source, such as welding gear, and place it outside of the working area. The same is true of brake fluid which is highly flammable, as well as corrosive to paintwork, and your eyes and skin. Obviously, do not smoke anywhere near a flammable liquid, or a fuel tank that may

still have vapour inside. Never forget to wear appropriate safety clothing, including goggles if you are cutting or grinding, and gloves if you could hurt yourself on another part of the vehicle if, for instance, a spanner slips: skinned knuckles are no fun. Wearing a mask prevents the inhalation of harmful brake dust, and you should dispose of any dust carefully after working on drum brakes.

Also, when working on brake components, make sure that you do not handle brake friction surfaces with oily or greasy hands as this will contaminate them and reduce braking efficiency. When replacing worn brake shoes, ensure that the replacements are made from asbestos-free friction materials for future safety.

Never work under an unsupported car – always use axle stands, and chock the wheels that remain on the ground. Never lift a car by placing a jack under anything other than a strong-point of the vehicle, or it could collapse on you.

The importance of thoroughly cleaning components before working on them cannot be over-emphasised. When replacing components use a copper-based lubricant on bolt threads, etc., to make future disassembly easier. Do not do this, however, on torqued components, as this will reduce friction and fittings can be over-stressed when torque is applied. In this case, use a light oil.

Always follow the manufacturer's instructions carefully, and remember that changing component specification by modification is likely to void warranties. Make sure that you inform your insurers of any changes to vehicle specification, as this could affect your insurance in the event of a claim.

Ensure you read this book in conjunction with a comprehensive workshop manual, and do not attempt any work until you have read the whole book first. Make sure that parts you intend to use will do what you want, and will work in conjunction with each other – do

not create a dangerous vehicle.

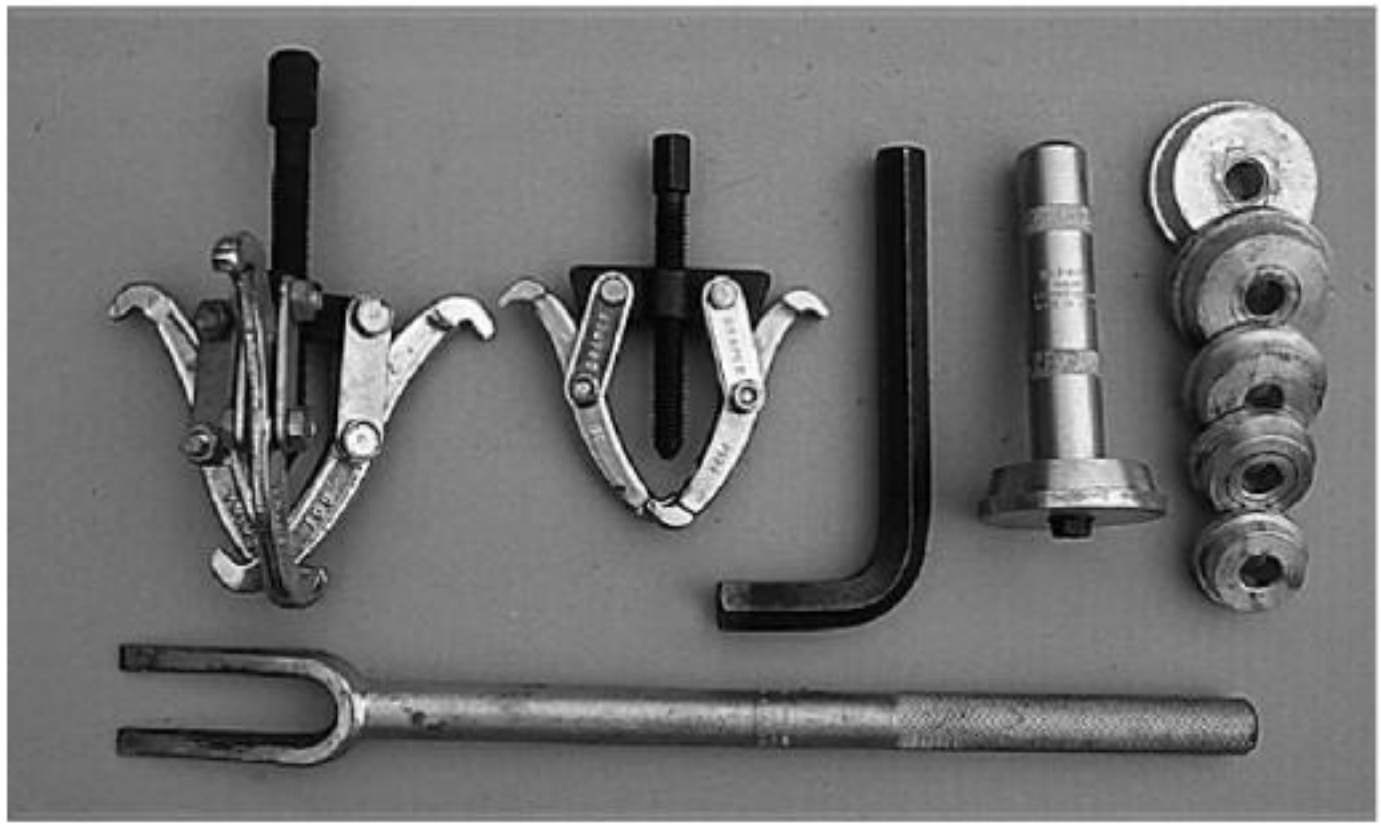
The publisher, author, editors and retailer of this book cannot accept any responsibility for personal injury or mechanical damage which results from using the book, even if caused by errors or omissions in the information given. If this disclaimer is unacceptable to you, please return the pristine book to your retailer who will refund the purchase price.

TOOLS

A kit of well-made tools will last a lifetime if looked after, and will pay for itself many times over. Always purchase the best tools possible within your budget, and shop around for the most attractive prices. Do not be tempted by cheap or poorly-made tools; the inevitable outcome will be skinned knuckles for you and a short working life for the tools.

For the type of work you will be undertaking whilst modifying your Beetle you'll need certain basics: a socket set, spanners (wrenches), screwdrivers, allen keys, pliers, internal and external circlip (snapring) pliers, and a fine drift. A selection of metric spanners will be needed including 10mm, 13mm, 15mm, 17mm and 19mm in open ended (crescent) and ring (box end) form. A pair of 27mm open-ended spanners will be needed if adjusting the front wheel bearings on early model Beetles. Metwrinch 4WD double-ended spanners (or similar products) are great for removing nuts that have rounded off, as they work on the nut faces rather than the corners.

You'll need a range of sockets, attachments and extensions, including a 36mm socket on a 3/4in drive bar to release Beetle rear hub nuts.



Bearing pullers, a large hex-key, a ball-joint separator, and a bearing removal and fitting tool are all great items to have in a toolkit for working on the Beetle.

The Torque-Meister tool is ideal for increasing the leverage on the 36mm rear hub nut, so that 30ft/lbs of applied torque will release the 270ft/lbs of torque at the nut.

Metric sockets in a variety of sizes will also be required. It's worth having a universal joint as well as a few extension bars to make life easier. A large 36mm socket on a long 3/4in drive bar is essential to undo the rear hub nut, and you can increase the leverage of this by using a length of pipe (scaffolding pipe about 6ft long is ideal), slipped over the drive bar. An alternative is a special, US-made tool called a Torque-Meister, made of tough 4130 chromoly steel which works on a toothed gear bolted to the VW brake drum. Turning the

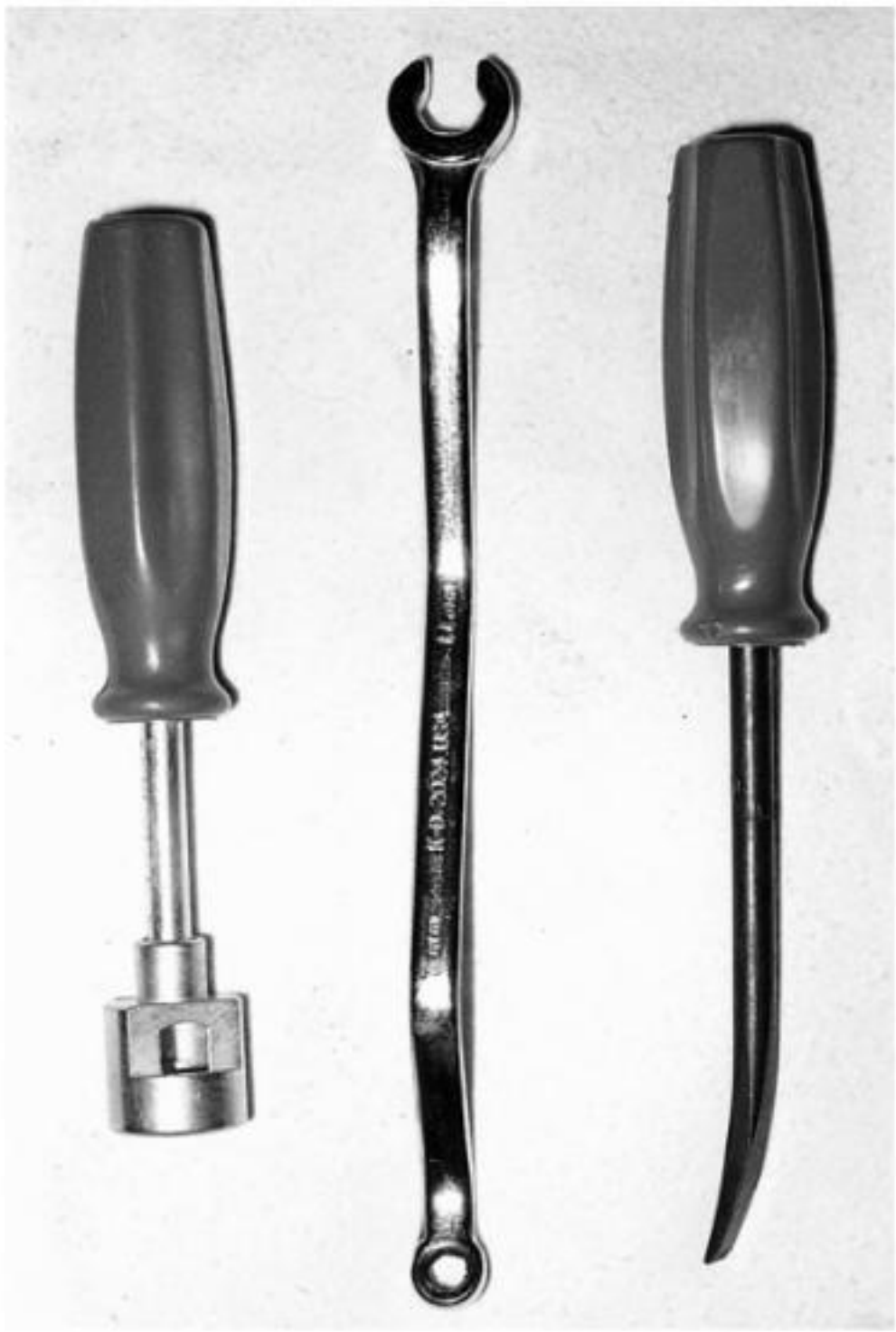
gear with a 3/4in ratchet at 30ft/lbs applies 270ft/lbs of torque at the hub nut to loosen it. Whilst a separate torque wrench should still be considered essential for your toolkit, this device is a blessing for any mechanic who regularly has to work on Beetle rear brakes.

Two other sockets that are necessities are a special splined tool bit that fits the hex-head bolts holding the IRS CV joints to their flanges, and a 45mm socket which acts as an ideal drift for fitting hub bearing races. An alternative to this tool is a special bearing race removal and fitting tool which features changeable flange sizes to allow working on a range of bearing sizes. The 1/2in socket drive ratchet bar is the most useful in any toolkit. It can be used with or without an extension, and takes all 1/2in drive sockets, including screwdriver or hex bits mounted in a special socket attachment. Hex bits also work with an impact driver, which is a useful tool when extra turning force is needed. Small 1/4in drive sockets are good in certain situations, such as stripping early disc brake calipers.

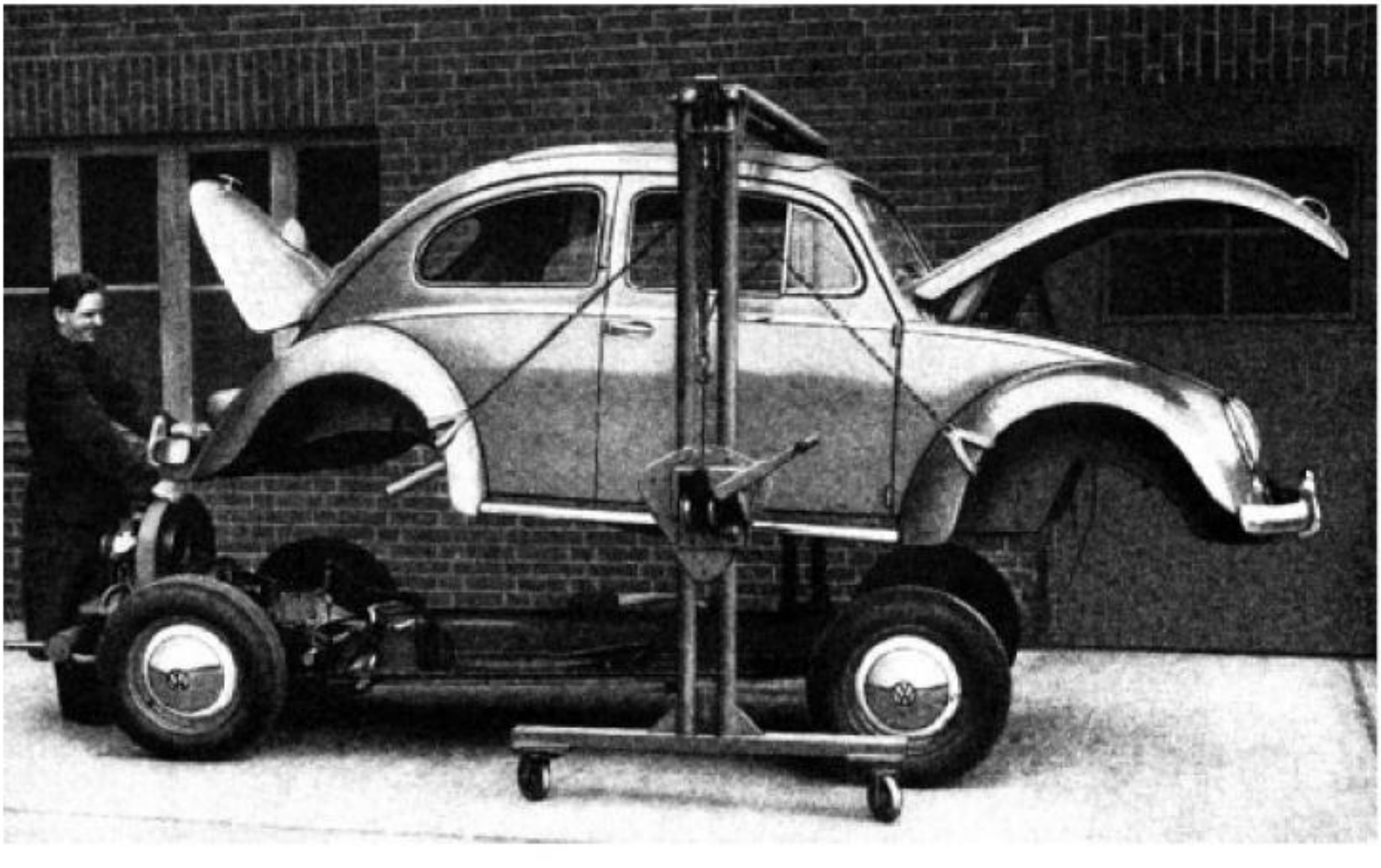
Some tools, such as axle (jack) stands and a trolley jack, can be rented and are necessary for many jobs when a vehicle has to be lifted and supported safely. An inspection lamp is also a worthwhile investment.

Other recommended tools include a 19mm hex key or socket (which fits both the A-arm pivot pins and the gearbox plugs) and brake tools (an adjuster for quick turning of the brake 'star' adjusters, a brake shoe retaining clip remover and a bleed nipple spanner). For working on the MacPherson strut Beetle front springs, a coil-spring compressor is also a necessity in order to remove springs safely. Work on the rear suspension calls for a camber-adjustment protractor, if accurate setting of the suspension is to be undertaken and adjustement on both sides of the vehicle equalised:

this tool can be hired. For work on ball-joints, separators will be required, and these come in a variety of styles, from units that progressively wind the joint apart, to the more brutal 'pickle fork' style which lever the joints apart but inevitably damage the seals. The former appears the more attractive but, in practice, the latter is far more effective and often the only option when components refuse to come apart.



Useful brake tools include: brake 'star' adjusters, a brake shoe retaining clip remover, and a bleed nipple spanner.



The ultimate VW Beetle tool. Although hard to find and store in the tool chest, it saves a lot of work when body removal time comes. (Courtesy Walter Bach)

Don't forget a few pairs of locking-jaw pliers (Mole grips). Their locking capability is a godsend in certain situations, and they come in different sizes and jaw sizes such as straight, curved, or long-nose for different applications.

Finally, before you head for the workshop, consider having a range of pullers to hand. These are often overlooked, but can quickly resolve an otherwise impossible situation when a brake drum or bearing refuses to move.

If in doubt about the use of certain tools for specific applications, check with a tool retailer or manufacturer, or a qualified mechanic.

Chapter 1
Chassis, suspension & brake design

THE CHASSIS

The VW Beetle, originally designed by Dr. Ferdinand Porsche i-n the 1930s, is as unusual in its mechanical construction as it is in looks. The now familiar, rounded shape of the bodyshell was designed to form a complete, rigid structure when bolted together, with a light platform chassis acting as a stressed member. By designing the bodyshell panels with compound curves to make them both stronger and more aerodynamic, it meant that the traditional type of heavy girder chassis could be dispensed with.

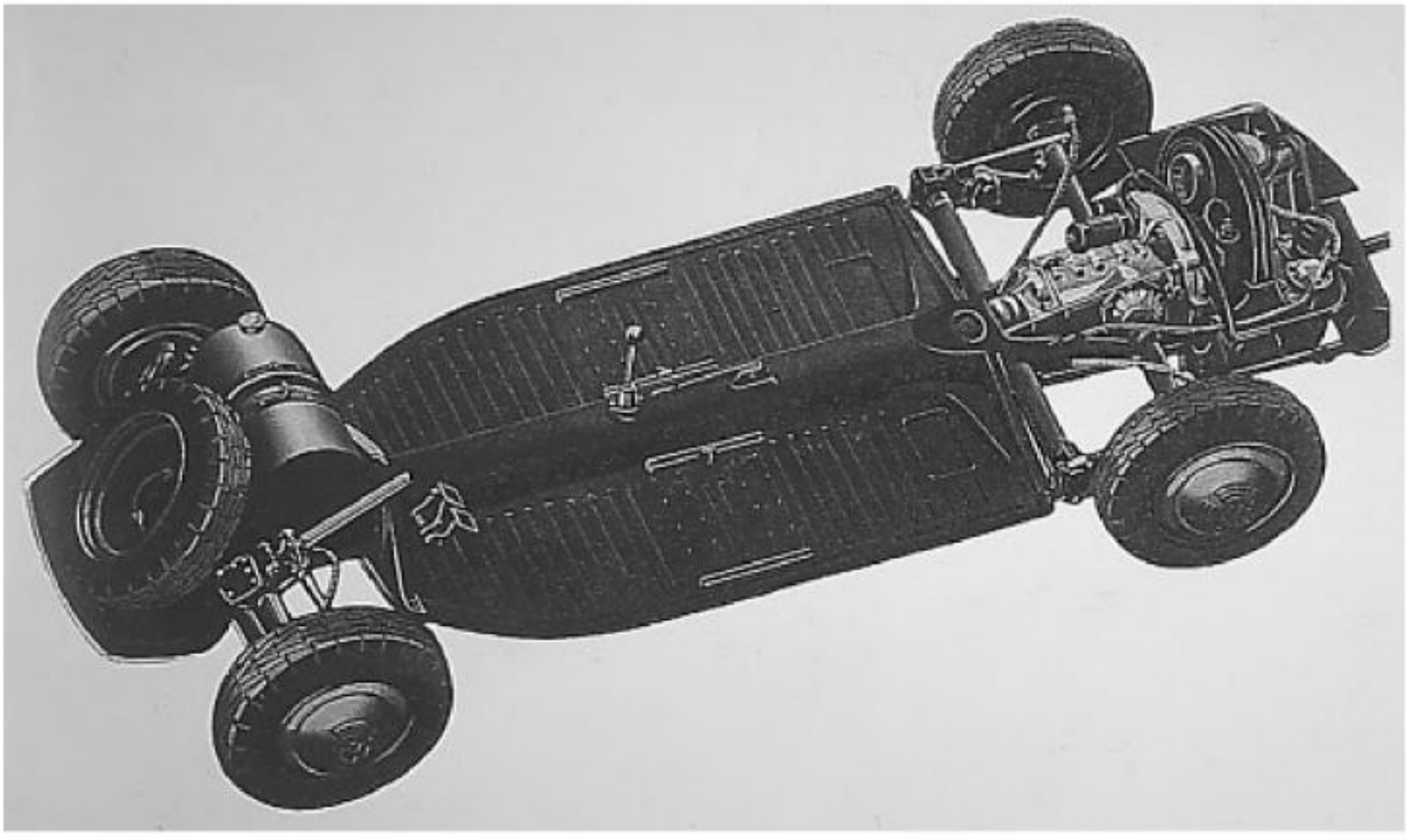
From a servicing point of view, the combination of a separate chassis and body offers considerable advantages in the event of damage to the body or frame, as either can be replaced independently.

The Beetle shape has remained much the same throughout its long production life. This is a 1953 model. (Courtesy Beaulieu Picture Library)

The chassis - which is essentially a single backbone frame for torsional rigidity - carries electrically welded-in pressed steel platforms which form the floor, and on which the seats are mounted. These 'floorpans' are also strengthened by the addition of a 'U' section around the edge, through which the body is bolted down. The central backbone tunnel, stamped to form the upper half of a tube and with a reinforced bottom plate welded to it, not only gives strength to the chassis, but also provides the location for the accelerator, clutch and heating control cable conduits, the main fuel line running from front to back of the vehicle, and the gear linkage

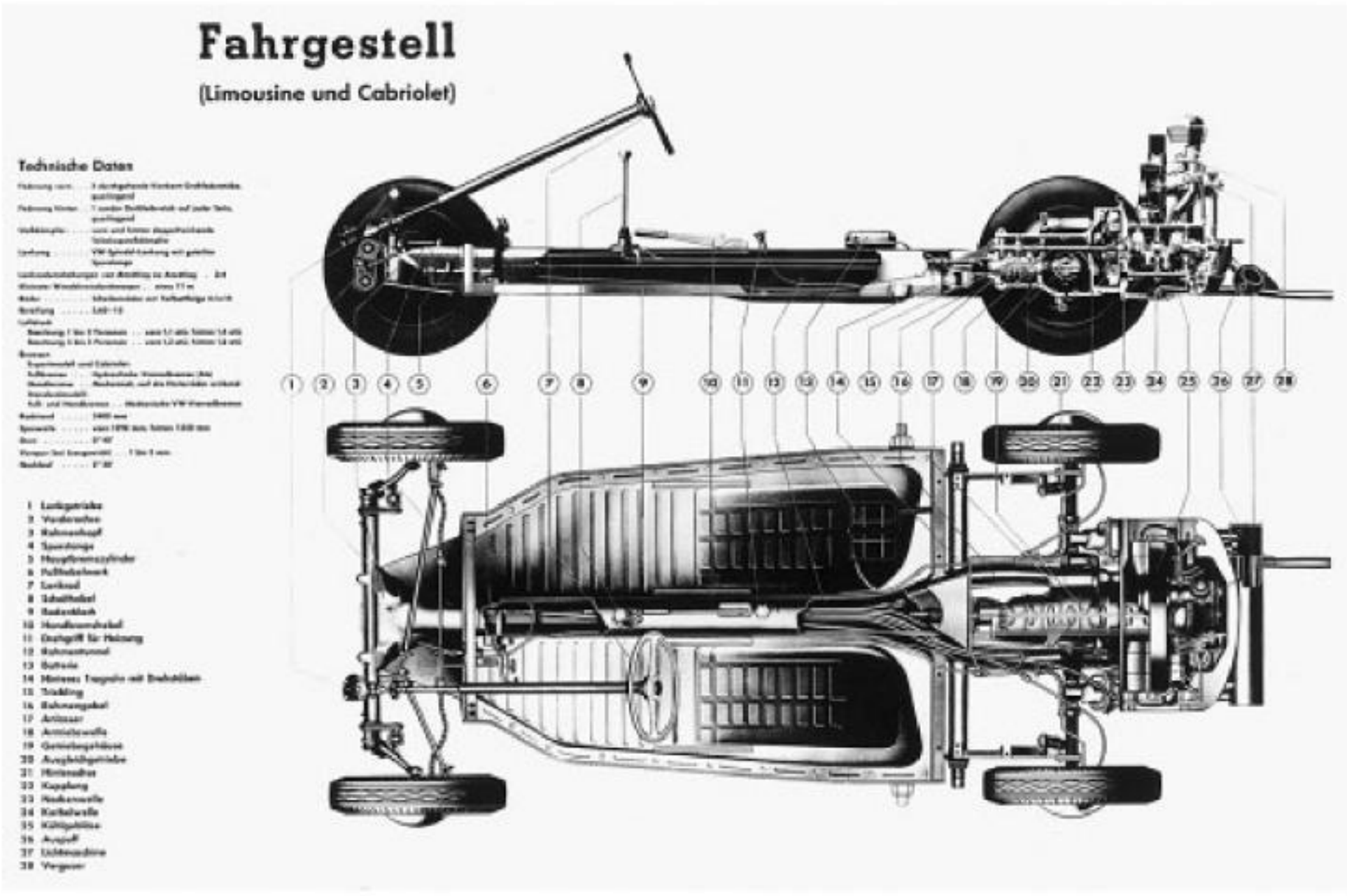
and supporting bush.

Handbrake cables also run in conduits from a point halfway along the tunnel length to exit at the rear of the chassis, and thence to the wheel hubs situated on the outer end of the axles. The handbrake lever itself, gearshift and heater controls are all mounted to the top of the central tunnel at a point within reach of the driver. The earliest 'Standard' model chassis also carried the rods and bowden cabling for the braking system inside the backbone, until the move to a simplified, and more effective, hydraulically-operated ATE non-servo drum brake system in the mid-1950s. The brake pipe running the length of the vehicle was then mounted next to the tunnel, but on the outside for easy access.



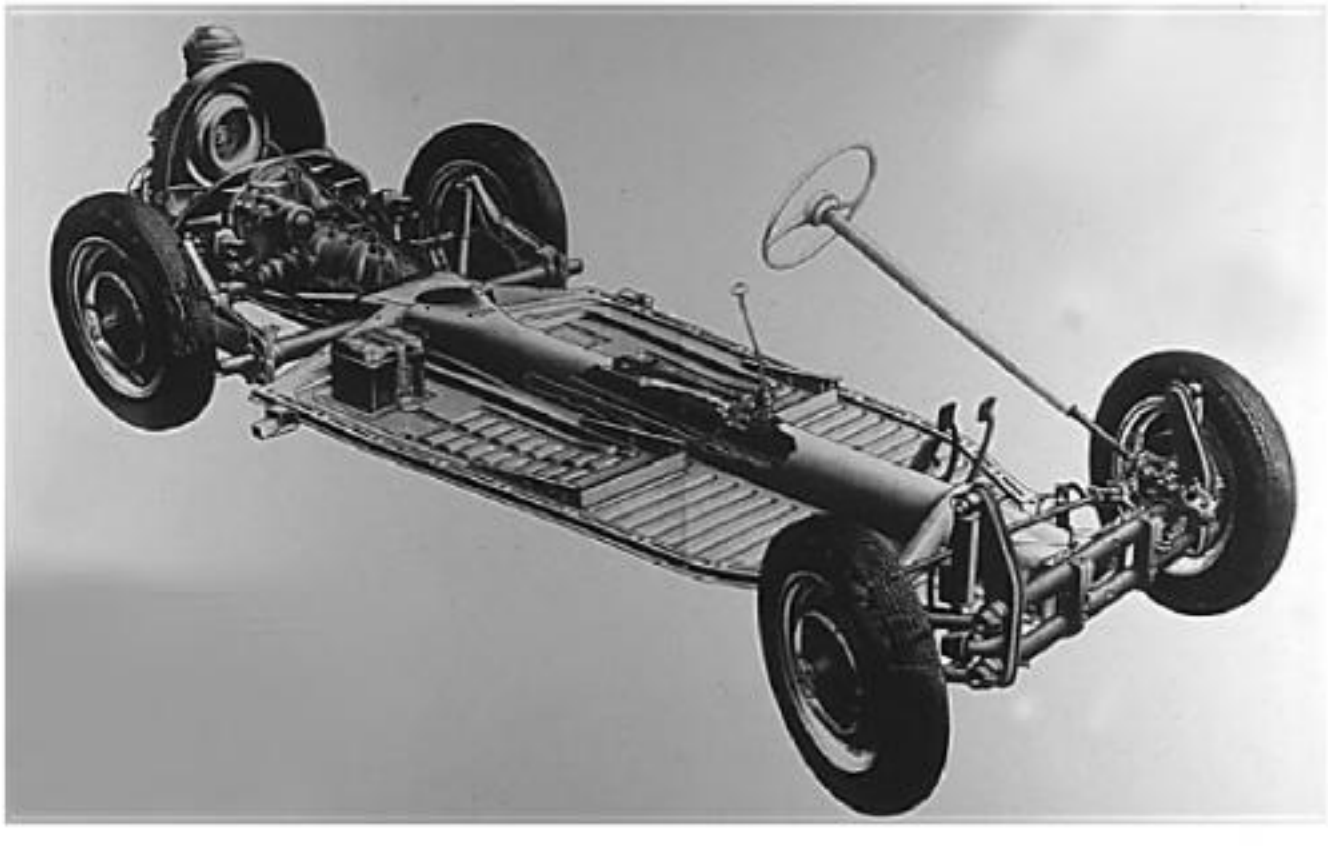
Originally designed in the 1930s, the basic design of the chassis floorpan with suspension, steering, fuel tank and spare wheel

at the front, and transmission and engine at the rear, still continues in production at the time of writing.



A German diagram of the Beetle chassis showing the control cable conduits running within the central backbone. (Courtesy Stiftung AutoMuseum Volkswagen)

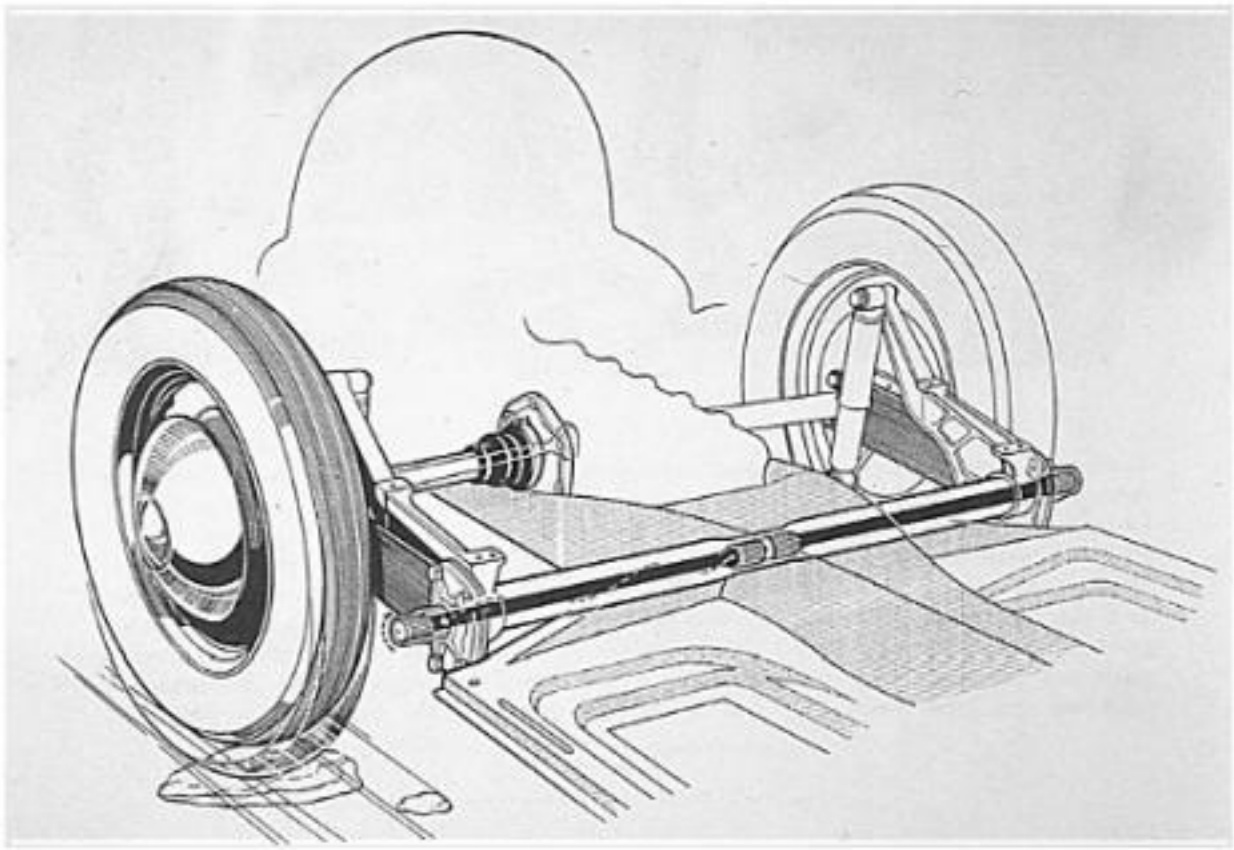
The oval window design, intended as a safety feature increasing rear visibility, replaced the earlier split-screen rear in 1953. The cable operated drum brakes, however, probably did little to inspire driver confidence. (Courtesy Beaulieu Picture Library)



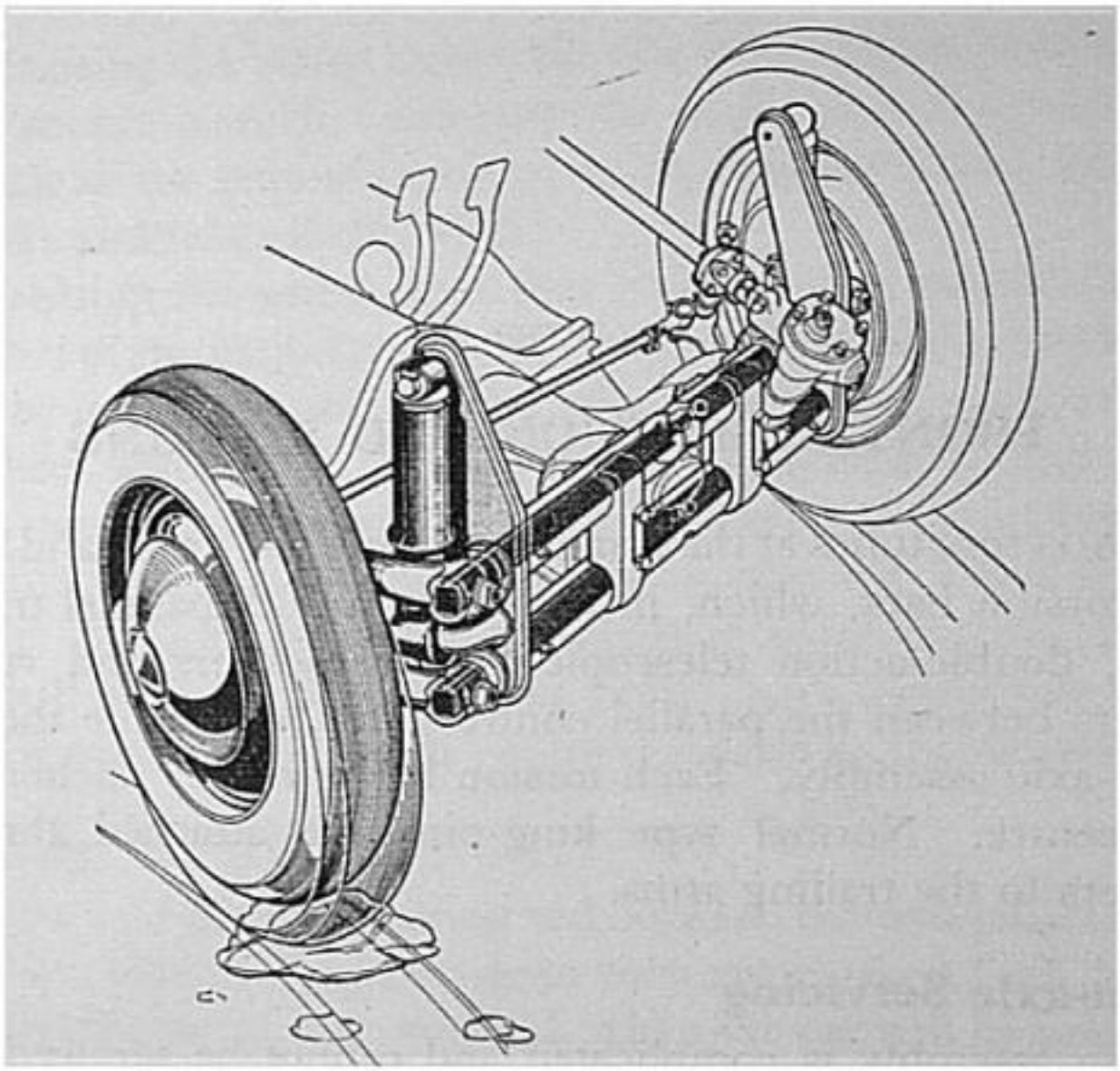
This early VW promotional diagram of the chassis and running gear features cutaways to show off the Beetle's engineering vitals.

At the front of the platform, the central tunnel widens to form a frame-head which provides the mounting points for the front suspension assembly. The front suspension - made up of two tubes containing torsion-bars, one above the other - is positioned forward of the front bodyshell bulkhead, which allows for the fuel tank and luggage storage within the vehicle under-bonnet area.

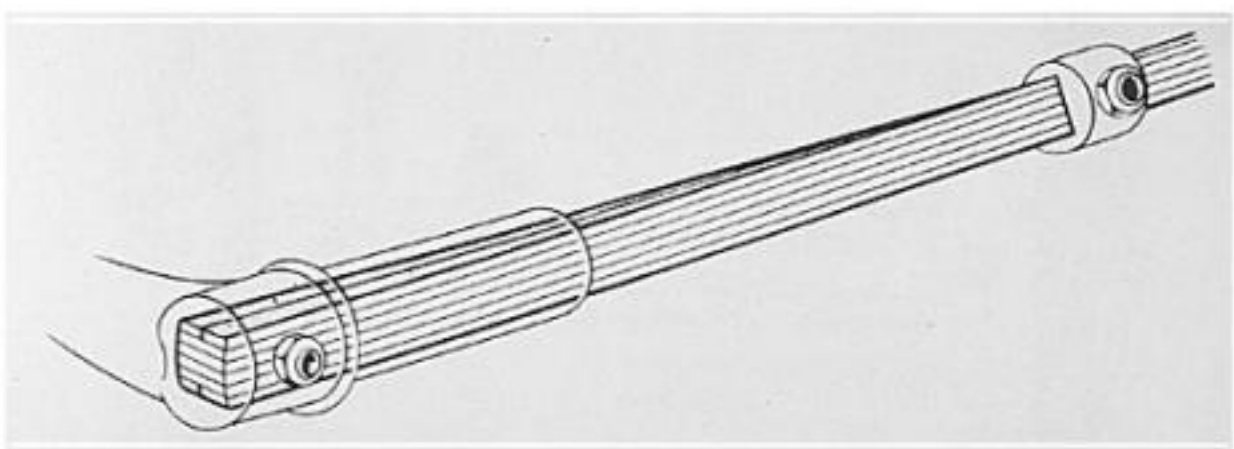
At the rear of the chassis, the backbone splays out into a forked member, providing a cradle to support the transmission. The gearbox is attached to the chassis at three strategic points: one beneath the fork of the chassis and the other two on a removable support bolted across the very ends of the fork. Mounting blocks made of rubber-faced steel help insulate the inside of the car from engine and gearbox vibration. The coupling mechanism between the gear lever change rod and the gearshift lever of the gearbox is accessible through an inspection plate situated on top of the rear of the tunnel. Attached to the bell-housing end of the gearbox is the Porsche-designed, horizontally-opposed, four-cylinder, air-cooled engine. This was initially of 1131cc capacity in postwar 1949 'split' rear window Beetles.



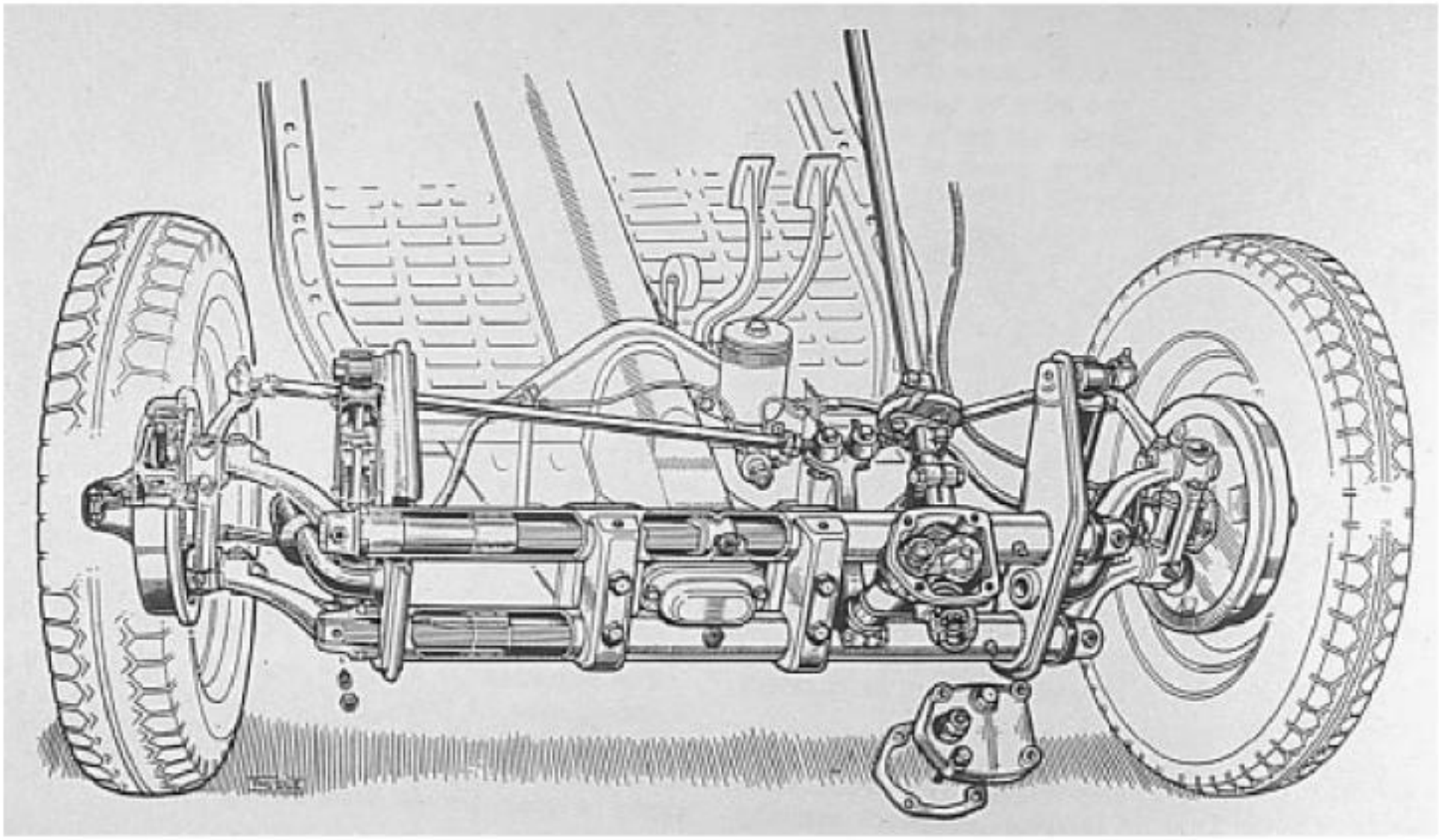
The torsion bars of the rear suspension locate within horizontal tubes at the rear of the chassis and, with spring plate trailing arms attached to the axle tubes, act as a swing axle design.



The Porsche-designed front suspension is very strong, and gives a comfortable ride on all types of road surface. A similar design was used on Porsche's own cars.



The Beetle's front torsion-bars were made up of flat steel leaves, one above the other, held at the centre inside each front axle tube. Cars of different years have different numbers of leaves.



A cutaway view of the early king and linkpin-type Beetle front suspension and steering gear. This was later modernised to a ball-jointed design.

Racing events, such as the January 1954 Monte Carlo rally, proved the durability of the Beetle suspension and engine. (Courtesy Beaulieu Picture Library).

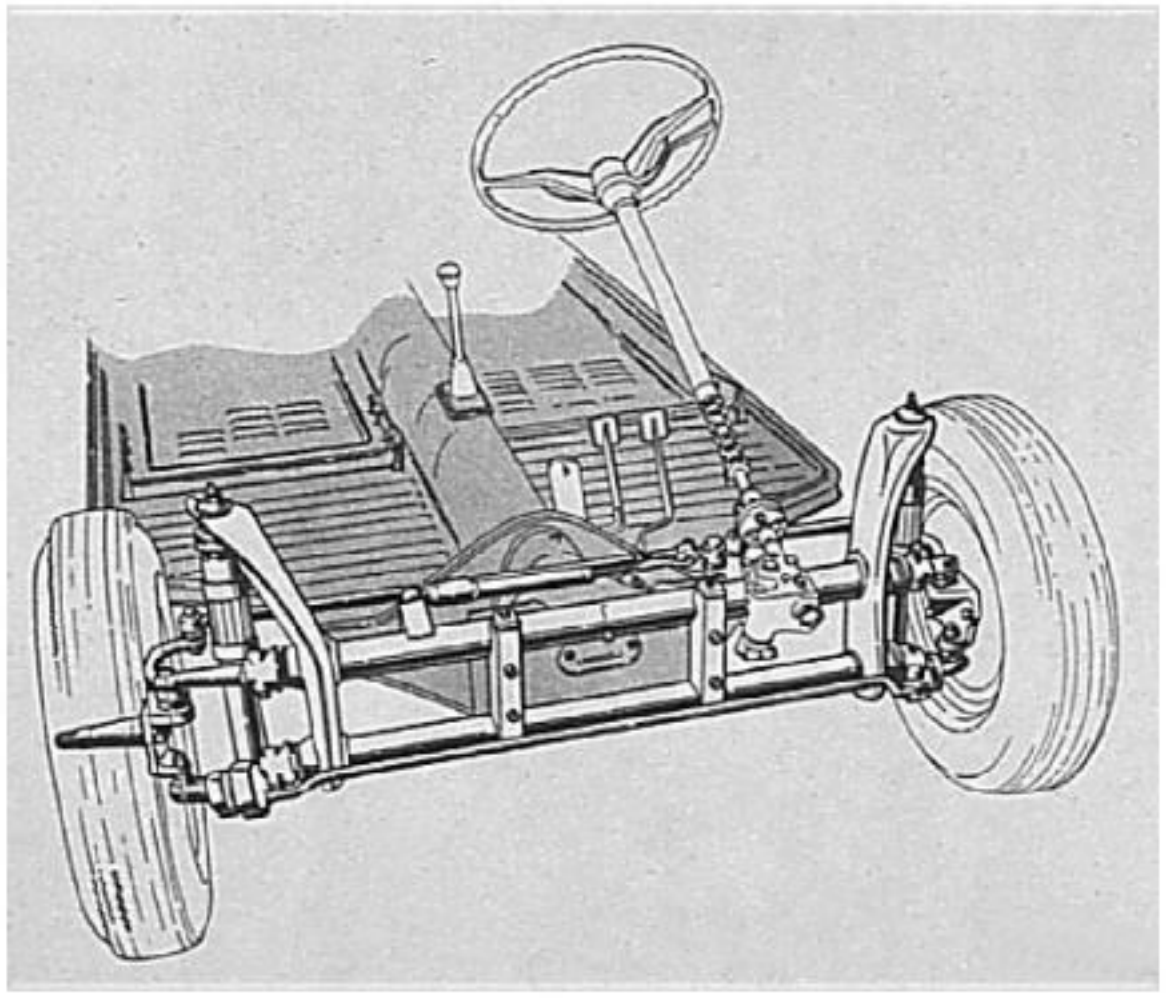
Also at the rear of the chassis is a pair of transversely-mounted solid torsion-bars with trailing arms, one on each side of the car. Located in strong tubular housings, and fixed at the inner end by a set of splines, the outer torsion-bar end is also splined, to accept the single trailing arm spring plate carrying the rear wheel hub and brake assembly.

Steering gear

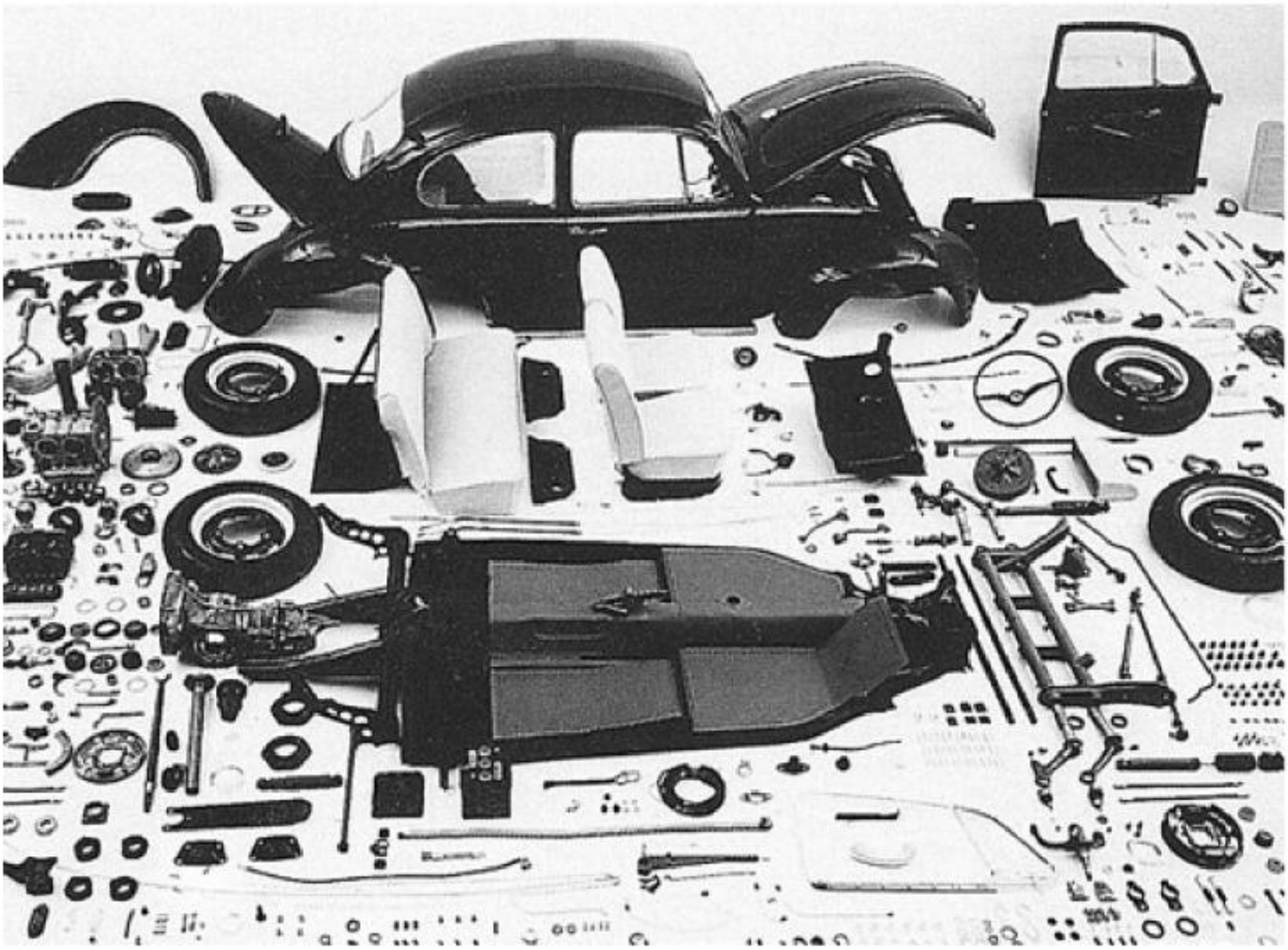
The steering gear was designed on the worm and sector principle (later changing to a worm and roller), with the steering gearbox mounted by a clamped section to the upper front torsion tube. Turned by the steering wheel, the steering column operates on the

gearbox shaft via a flexible coupling. Inside the box, the helical thread on the shaft gives forward or backward motion to a splined sector shaft, and thus to the drop arm beneath the unit. Unequally divided track rods, with adjustable ball-jointed ends, transmit the steering movement to the steering arms of the stub-axle assemblies.

The classic 1960s Beetle with king and linkpin front suspension, and swing-axle rear suspension. Many of the components can now be upgraded with high performance parts. (Courtesy Beaulieu Picture Library)



In 1966, the Beetle received a major overhaul in terms of body design, and suspension. Disc brakes appeared on the new 1500 model and were transferable to any other ball-jointed front suspension model.



This VW advertisement shows the number of separate parts that went into the making of a Beetle. (Courtesy Walter Bach)

BRAKES

Apart from the very earliest Beetle chassis, which used cable-operated brakes, braking is courtesy of a hydraulic system, operating on all four wheels. Pressure applied to the foot brake – part of the pedal cluster situated to one side of the central tunnel – acts on hydraulic fluid in a closed system of rigid and flexible pipes via a master cylinder. In turn, this operates individual wheel cylinders within each brake drum, forcing a leading and trailing

brake shoe within each drum against the metal drum friction surface. A cable-operated handbrake acts on the shoes within the rear drums only, when the handbrake lever is raised.

Front disc brakes first made an appearance on the 1500 Beetle in 1966, using the ball-jointed stub-axles previously seen on the VW Karmann Ghia model. These greatly improved the braking power of the vehicle, even though the calipers were only of twin-piston design. Other than on the 1500, disc brakes were only to appear on the GT model Beetle, and as an option on the 1300 model, as well as the later 1302S and 1303S MacPherson strut models. This allowed the Beetle design to be updated to meet changing performance and safety standards in its main markets.

1966 also marked the change from the large diameter 205mm five-bolt pattern of the Beetle wheels and corresponding wheel hubs, to a smaller diameter 130mm four-bolt fitting.

SUSPENSION

Front suspension

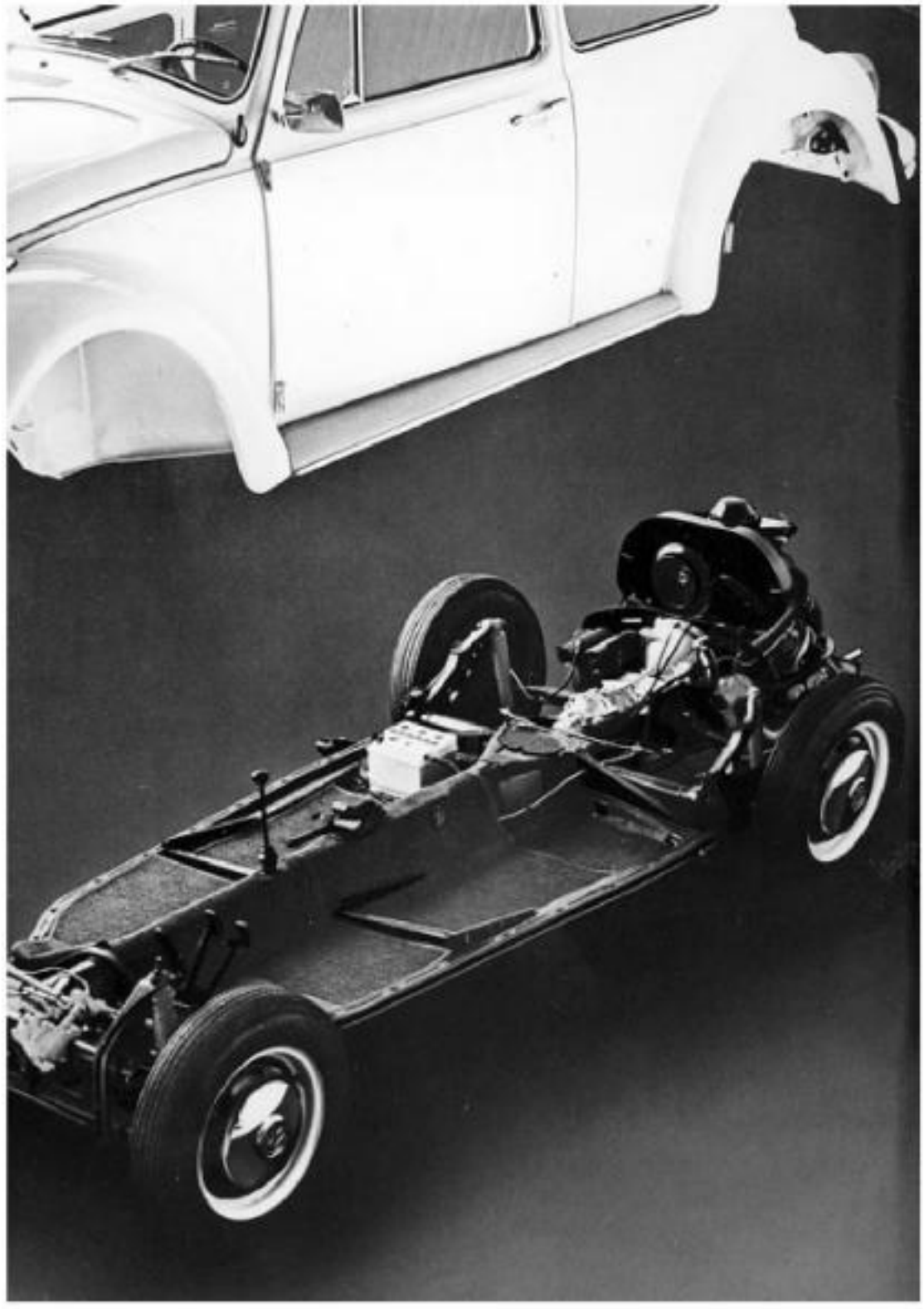
Apart from the MacPherson strut front suspension models first made available in the 1970s, all VW Beetles have torsion-bar front and rear suspensions. Use of this well-engineered torsion-bar system was, perhaps, unsurprising. The front suspension was Porsche's own patented independent system, providing a lightweight and compact design which allowed maximum space within the vehicle. The two bars are safely contained within transversely-mounted tubes to prevent damage, and allow more control and less wear than Porsche's earlier experiments with a single bar. The two parallel tubes running across the car are rigidly joined together and bolted across the chassis frame-head. Each houses a composite torsion-bar made up of a number of thin

leaves, which are secured in the centre of the tube to an anchor block by a dogtooth screw and locknut. This gives the effect of two torsion-bars from one assembly, making four bars in all.

Unlike conventional and heavy springs of the day, which gave a very firm ride and poor handling for a heavily laden vehicle, the VW torsion-bars stopped excessive wheel hop and reduced roll, giving a ride that was good over rough ground, yet soft enough to give a comfortable ride on proper road surfaces. They also ideally suited the lightweight vehicle as the torsion-bars - essentially a spring made up of straight bars of tempered metal – gave a rising rate springing effect. Fixed at the centre, the leaves of the bar resist the twisting force exerted on the other end as they are deformed by the motion of the wheels on the ground. The design ensures that the more the suspension is twisted, the greater the spring rate becomes. This characteristic of the suspension was a huge asset to VW when the chassis became the basis for the rugged Kubelwagen during the war and, more recently, on competition-winning dune buggies raced in demanding off-road terrain.

The earliest Beetle design used just four leaves in each torsion tube, pivoting on bearings inside each, but this was quickly increased to six as mainstream production began. To provide an even softer ride, post-1966 Beetles used a total of ten leaves, made up of four large leaves and six half-leaves within each set. The torsion-bars are mounted at each end of the trailing arms, secured by dogtooth screws and locknuts, and to which the stub-axle assemblies are mounted.

The 1967 US–spec. Beetle was the last US model to feature swing-axle rear suspension, before safety legislation meant a move to the IRS design. (Courtesy Beaulieu Picture Library)



The body is secured to the floorpan, and to the front and rear suspensions, by a series of bolts around the outer perimeter. This is a 1968 model. (Courtesy Volkswagen AG)

Prior to 1966, assembly was designed to use adjustable link pins and bushes, horizontally-mounted, with vertically-mounted kingpins acting as steering pivots. After this date, conventional ball-joints were used, with the top one mounted in an eccentric bush to allow adjustment to the camber/castor angles. Torsion-bar assemblies

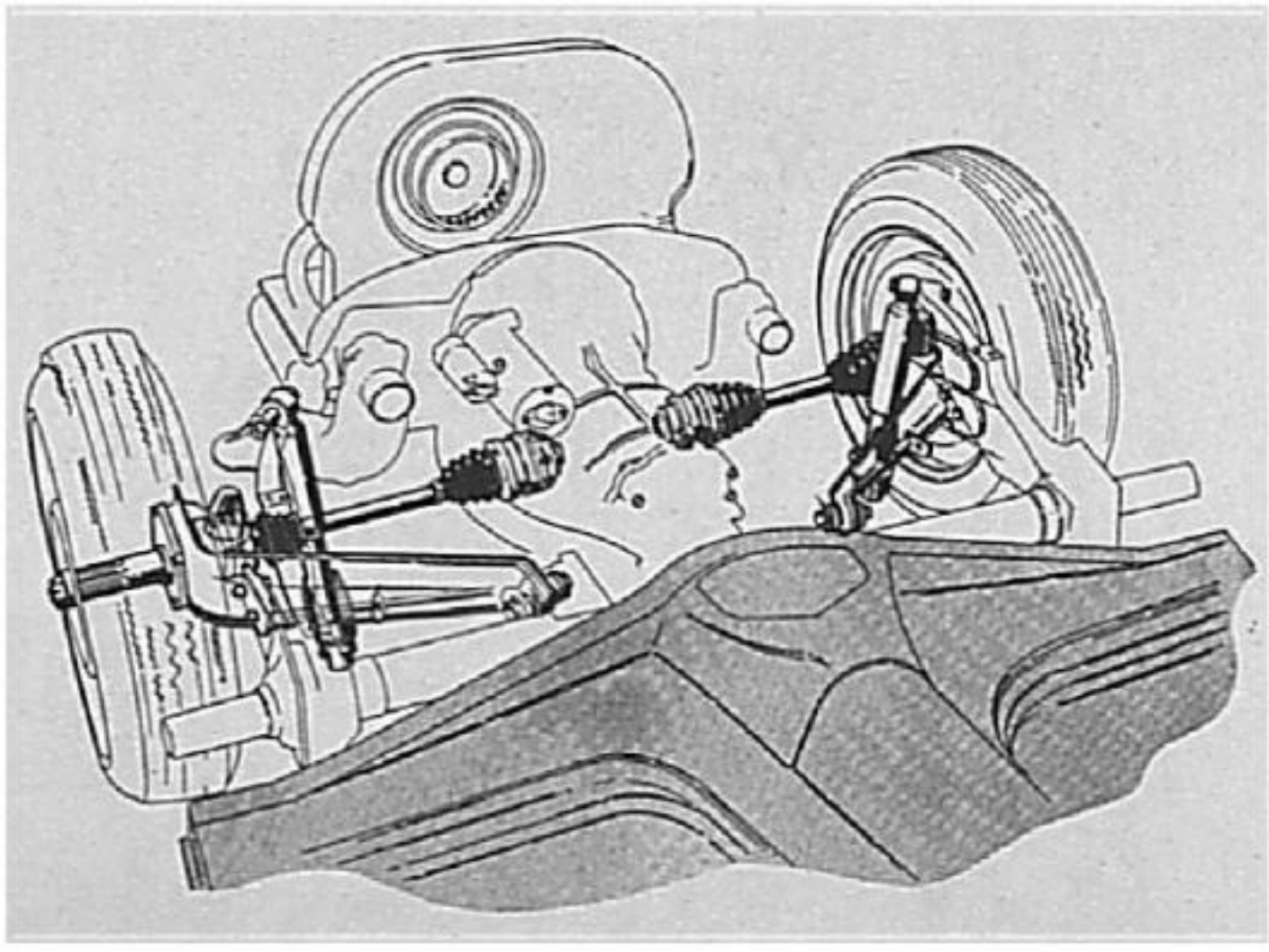
and trailing arms before and after this milestone date in VW Beetle production are not interchangeable. Spacing between the parallel bars of the early or later type differs considerably, with the frame-head of the chassis being designed to accommodate only either one or the other.

Shaped sideplates, vertical to the torsion tube assemblies, provide the top anchorage point for the conventional hydraulic telescopic dampers used at the front, though the post-1966 suspension incorporated bump stops into the units themselves, rather than being mounted between the trailing arms with a rubber block, as on earlier cars. To prevent roll, all Beetles from 1959 onwards use a stabiliser bar, attached to the lower trailing arms by rubber bushes and retaining clips.

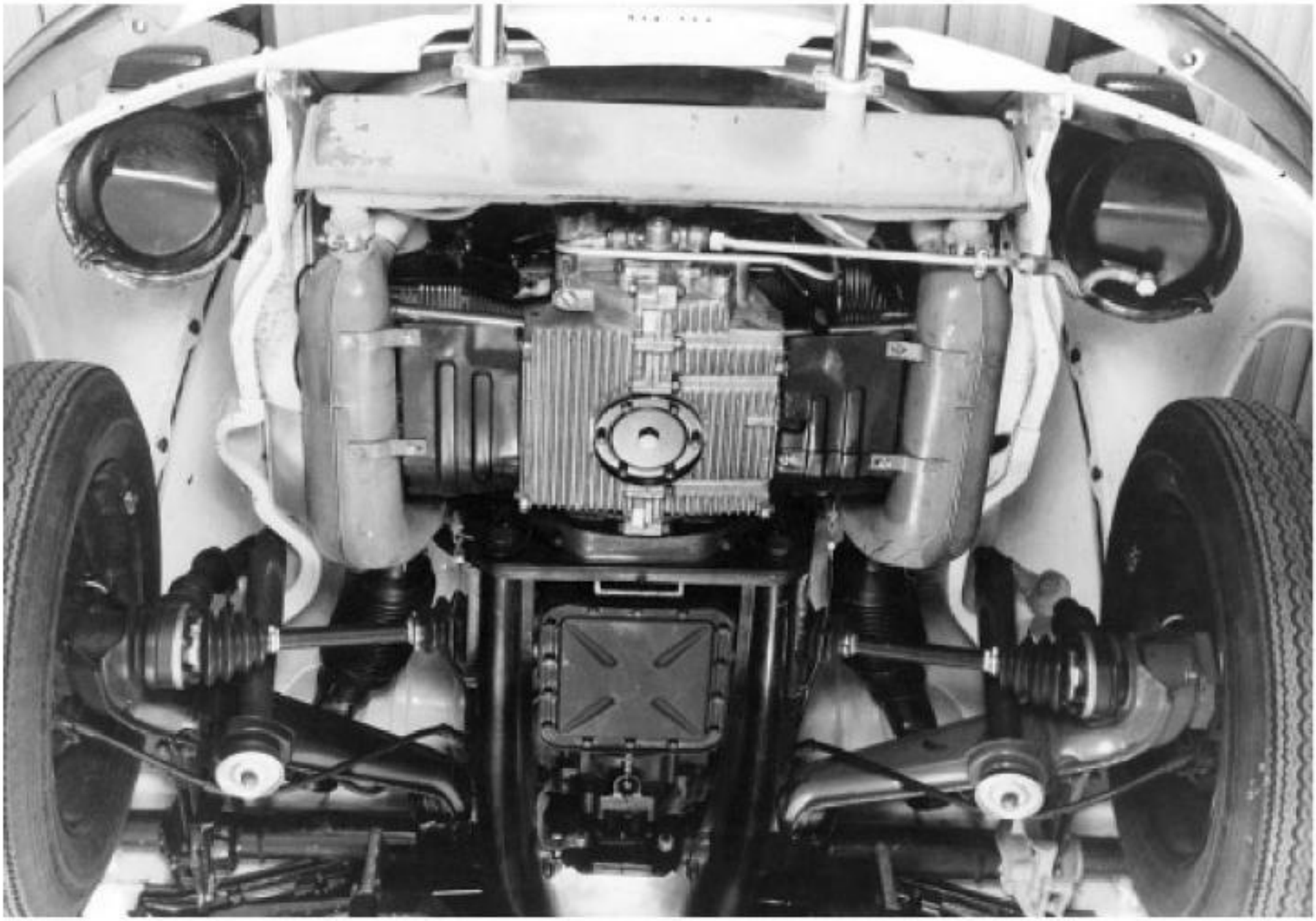
Rear suspension

The rear suspension of the Beetle, with its solid torsion-bar design, is mounted independently on each side of the floorpan with the inner ends of the torsion-bars secured by splines, carrying the single trailing arm spring plates via splines on their outer ends. The spring plates bolt to the transaxle outer axle tubes which carry the rear hub and brake assemblies, and feature elongated bolt-holes to allow for toe-in/toe-out adjustment. Inside the tubes run the solid one-piece axles which are driven at the transaxle end through a spade and socket type universal joint, whilst splining straight into the wheel hub brake drum at the outer end. Cheap to manufacture and with little maintenance required, except to replace the hub seals and axle gaiters which retain the lubricating oil within the axle tubes, the design does have one major drawback: as the rear suspension is raised or compressed, it describes an arc at the outer end, creating a high roll centre as the axle pivots at the transaxle.

The design does not allow for any sideways movement to correct such camber changes, due to the rigid axle tubes. These adverse camber changes result in the Beetle having a feeling of extremely nervous handling at the rear on uneven road surfaces, and particularly so in the wet.



Independent rear suspension (IRS) used constant velocity (CV) joints in the axles to allow better wheel geometry and to prevent adverse camber changes during cornering and on uneven road surfaces.



In Europe, the sophisticated diagonal trailing arm independent rear suspension (IRS) design was initially fitted only to the semi-automatic model. Widespread use on 1302/03 models followed later. (Courtesy Robin Wager)

Modifications to this design came in 1967 with the advent of the semi-automatic Beetle model, also known as the 'Stickshift' model. Unable to accommodate the revised axle position of the longer three-speed gearbox and torque converter, the conventional solid axles were replaced by a new design using a short, solid axle mounted between two constant velocity (CV) joints on each side of the car. The gearbox carries a flange on each side to which the

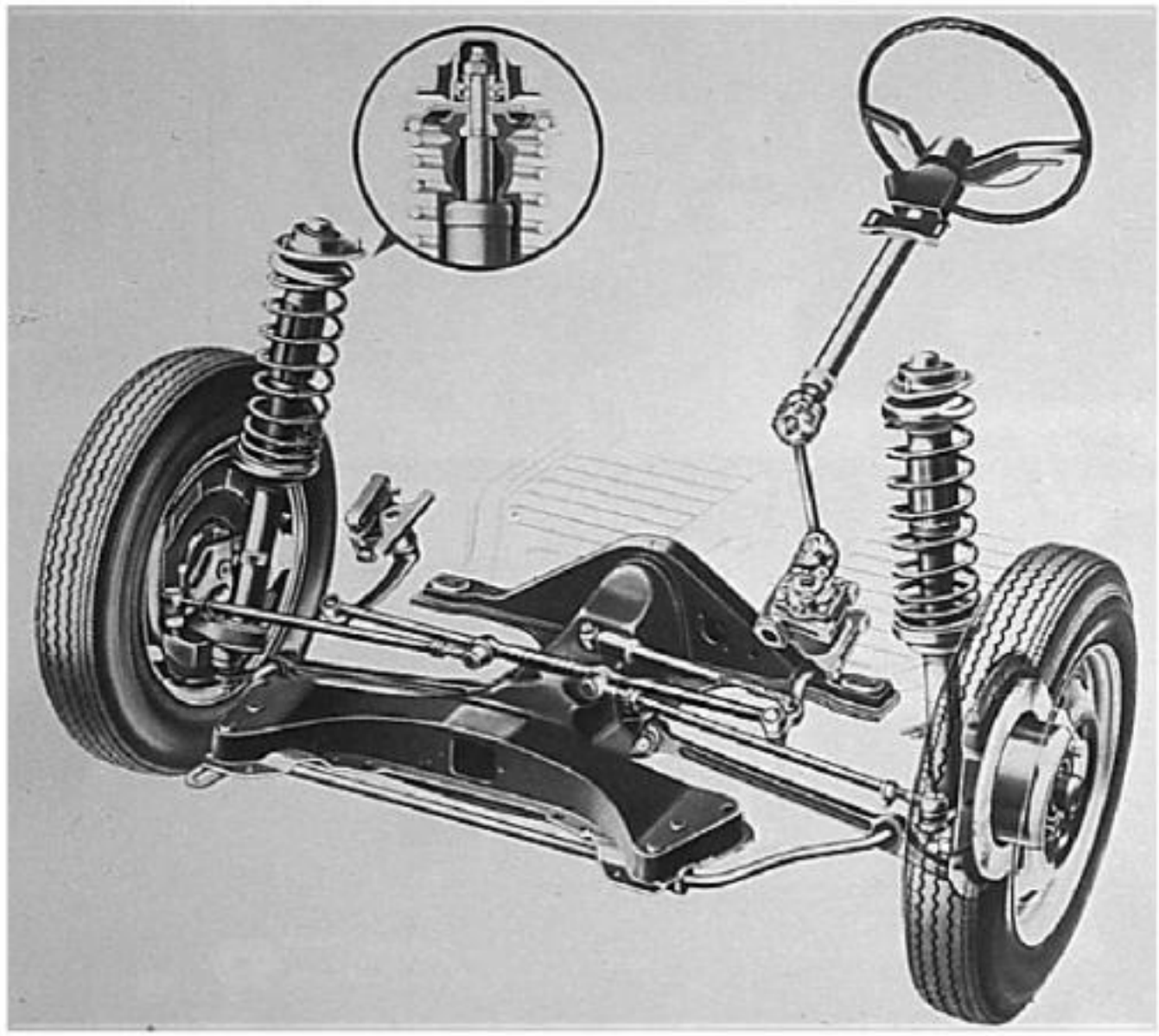
inner CV joints are bolted, whilst the outer two are bolted to similar flanges forming part of the two short, splined axles running in bearings mounted within hub carriers on either side of the vehicle, and to which the brake drums are mounted. The CV joints allow for angular movement of the axle as the suspension moves up and down, and therefore offers vastly improved road holding by minimising adverse camber changes. Often referred to as a four-joint rear suspension or Independent Rear Suspension (IRS), the latter term is not strictly correct as the swing axle suspension was also independent, but the general designation has now become the accepted term to describe this design.

With the rear hubs no longer laterally located to the transmission, semi-trailing arm arrangements (also referred to as diagonal A-arms) were introduced to connect the hub assemblies to chassis-mounted brackets at each side of the transmission fork abutting the torsion-bar tubes. Pivoting on bush-mounted pins, the semi-trailing arms complete the job of locating the road wheels. Unlike the front suspension, the spring plate and diagonal arms aren't fully trailing and give a small amount of toe-out to the wheel during travel. The sole purpose served by the axles between the CV joints is to transmit engine power to the wheels.

The semi-automatic option was offered on 1300 and 1500 Beetles, but the IRS design was quickly adopted into the US-spec. model range from 1968 onwards to meet increasingly stringent American vehicle safety standards. The design, apart from minimising camber changes and allowing superior roadholding, provided another benefit – that of making work on the transmission much easier, as it could now be removed from the vehicle without removing the whole transaxle. This meant that all other parts of the rear suspension were left attached to the chassis, and the vehicle

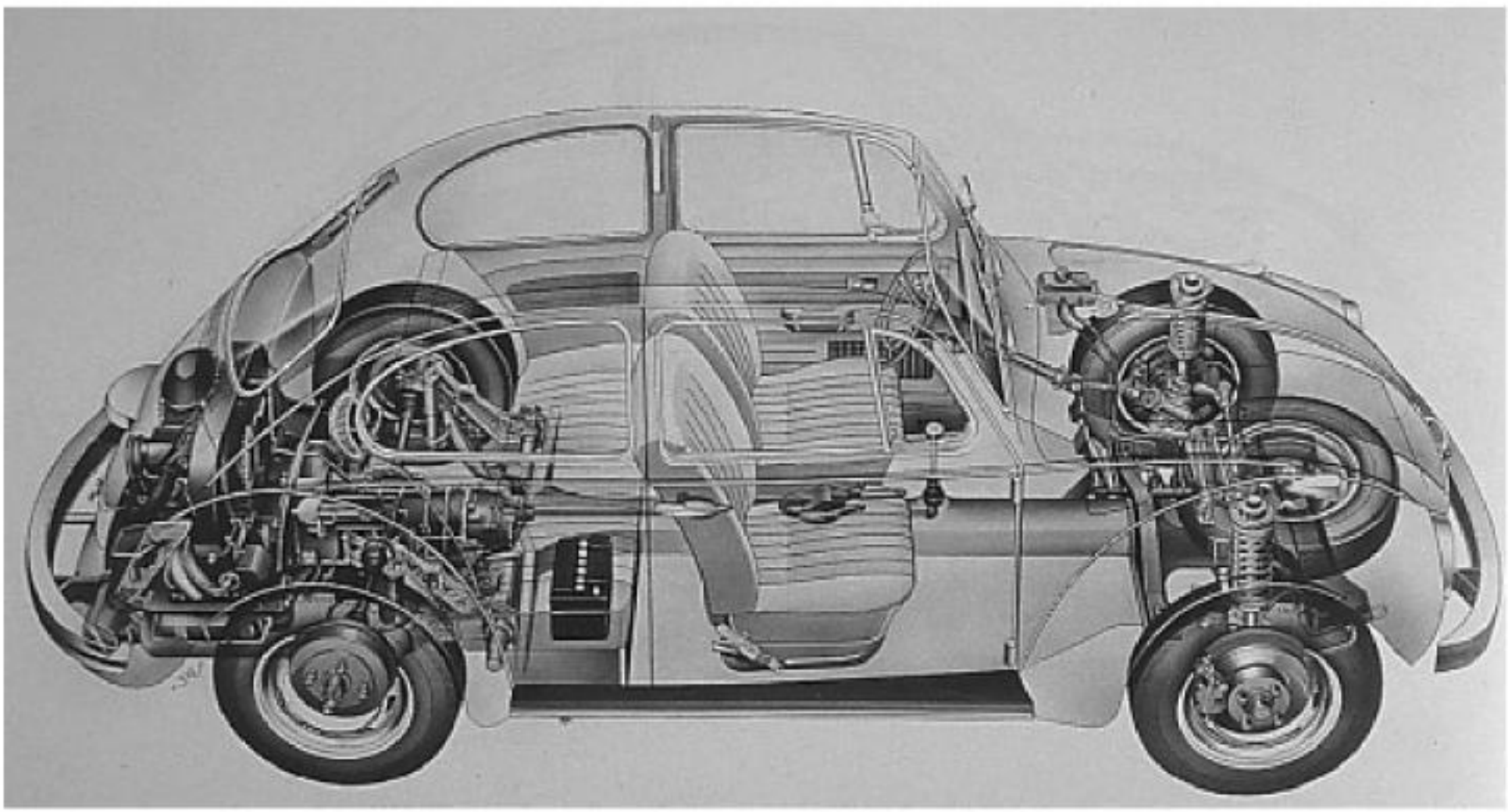
could remain on its wheels.

The 1970 Sun Sedan was the US-market sunroof Beetle. It featured ball-joint front suspension and IRS rear for better roadholding. (Courtesy Beaulieu Picture Library)



This illustration shows the MacPherson strut front suspension and the steering column on the later Super Beetle models, introduced for the 1971 model year.

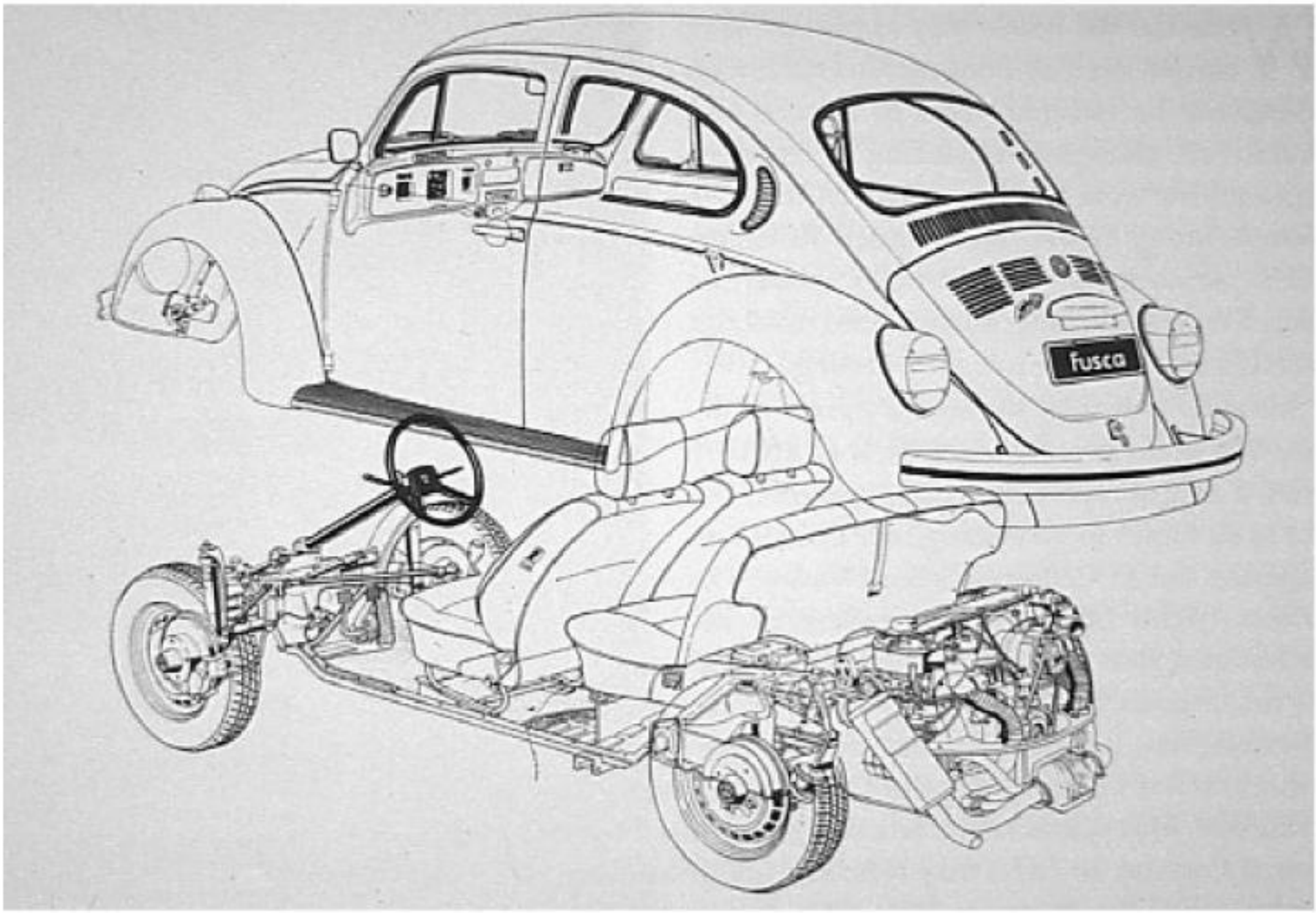
A cutaway Beetle showing the basis of the later design, including the safety steering wheel. (Courtesy Walter Bach)



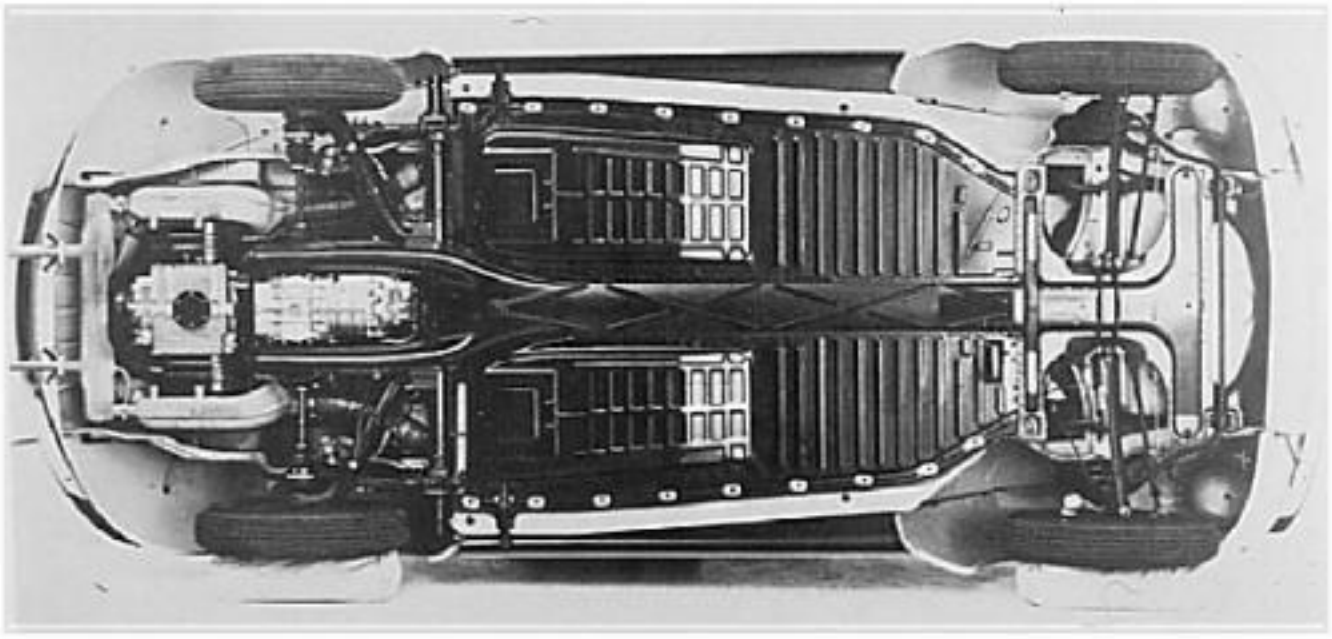
An illustration of the Super Beetle design. The model featured a modernised front suspension design, with the MacPherson strut suspension allowing more space under the front hood for luggage.

Beetle chassis with engine, transmission, steering, suspension and wheels fitted. This is a 1302 model with IRS rear suspension, and MacPherson strut front suspension. (Courtesy Simon Glen)

The 1303 model was the last major development of the Wolfsburg-made Beetles. It featured a panoramic windscreen and greater interior space due to the curved, padded dashboard.



Brazilian-made Fusca Beetles represent the most up-to-date development of the original design. They have, however, reverted back to the swing-axle rear suspension, although discs are now standard at the front.



This shot of the underside of the Super Beetle design shows the IRS rear suspension and the radically different front suspension design required to mount the MacPherson strut coil springs, the control arms and the stabiliser.

LATER VERSIONS

In a bid to modernise the Beetle, VW introduced a new model in 1970, with a radically changed front suspension design and updated overall look. The 1302, as it was named, had a larger front hood to give greater luggage space, and revisions to the front part of the chassis to accommodate the MacPherson strut front suspension. The rear suspension was the same IRS design as on the stickshift model which, combined with the modifications to the front, produced the most refined of all Beetle designs for roadholding. The 1300cc version of the 1302 design, together with the 1600cc 1302S, fitted with front disc brakes, provided greater driver comfort and luggage capacity but lacked the simplistic character and universal appeal of the earlier models.

A final version of the European-made MacPherson strut model Beetle appeared in 1972. Called the 1303, it was also produced in 1300cc and 1600cc (1303S) engine forms. Both the 1302 and the

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on the strip. They are supplied by Gene Berg Enterprises, and others, and are easy to fit. They simply slip behind the lower torsion-tube against the chassis frame-head and are sandwiched in place as the suspension is bolted up using longer-than-stock high-tensile bolts. The top bolts can remain original, as the shims are only used on the lower tube.

Once the trailing-arms are back in position, the front anti-roll bar (or stabilizer/sway bar) can be refitted, or one added if not originally fitted to the car, although all post-1959 Beetles came with them. An anti-roll bar can be thought of as a form of torsion-bar spring. When the car is in straight-line motion, both wheels of a pair move in the same direction and the bar is inoperative and has no effect. However, if one wheel moves up much more than the other, for example during cornering, the bar is twisted and resists this movement. The bar thus counteracts and/or influences the effects of weight transference on the vehicle whilst cornering, and helps control this lateral weight transference and reduce under- or oversteer.

Large diameter front anti-roll bars are available for cars that will see competition action or off-road use. Such bars come with urethane bushes, and are designed for standard and lowered suspensions.

To fit 'bump-steer' bushes, the steering arm eye has to be drilled out and the new bush fitted. This allows the track-rod end to be fitted from underneath the arm.

Owners of buggies, or cars that may see competition action, can fit larger diameter anti-roll bars to aid handling, and these are

available in different sizes starting at 3/4in, and fit every type of VW Beetle front suspension. They also come in different styles to suit both standard and lowered suspensions, and benefit by being supplied with urethane mounting bushes. Being a thicker bar, there is a greater loading applied to the tyres, which in turn increases the understeer of the car – no bad thing when the Beetle is known for its oversteer characteristics.

Remember to only use a bigger bar at the front if also modifying the back end with an anti-roll bar or camber compensator. The usual and most commonly available pairing is a 3/4in bar at the front, with a 5/8in bar at the rear (for IRS cars) or a camber compensator (for swing-axle cars). As well as reducing body roll, which is the main reason for fitting these devices, the front to rear balance of the car's handling is maintained or even improved, making it much more neutral. The tyres will have to work harder when cornering, but the wider wheels and tyres fitted to modified vehicles will normally be quite capable in this respect.

In all circumstances, make sure your tyre pressures are even, side to side, to give optimum roadholding.

Track-rods

If the whole front suspension is to be rebuilt, then the track-rod ends should be replaced prior to refitting the track-rods themselves, but this is the point at which another problem may become apparent. Depending on the amount of lowering of the front suspension, the track-rods, which normally adopt a position parallel to the ground when at rest (and viewed from the front of the car), will now no longer be level, and will rise upwards at their outer ends where they meet the steering arm of the stub-axle. In normal movement, as the wheels rise they lift the track-rods where they fix

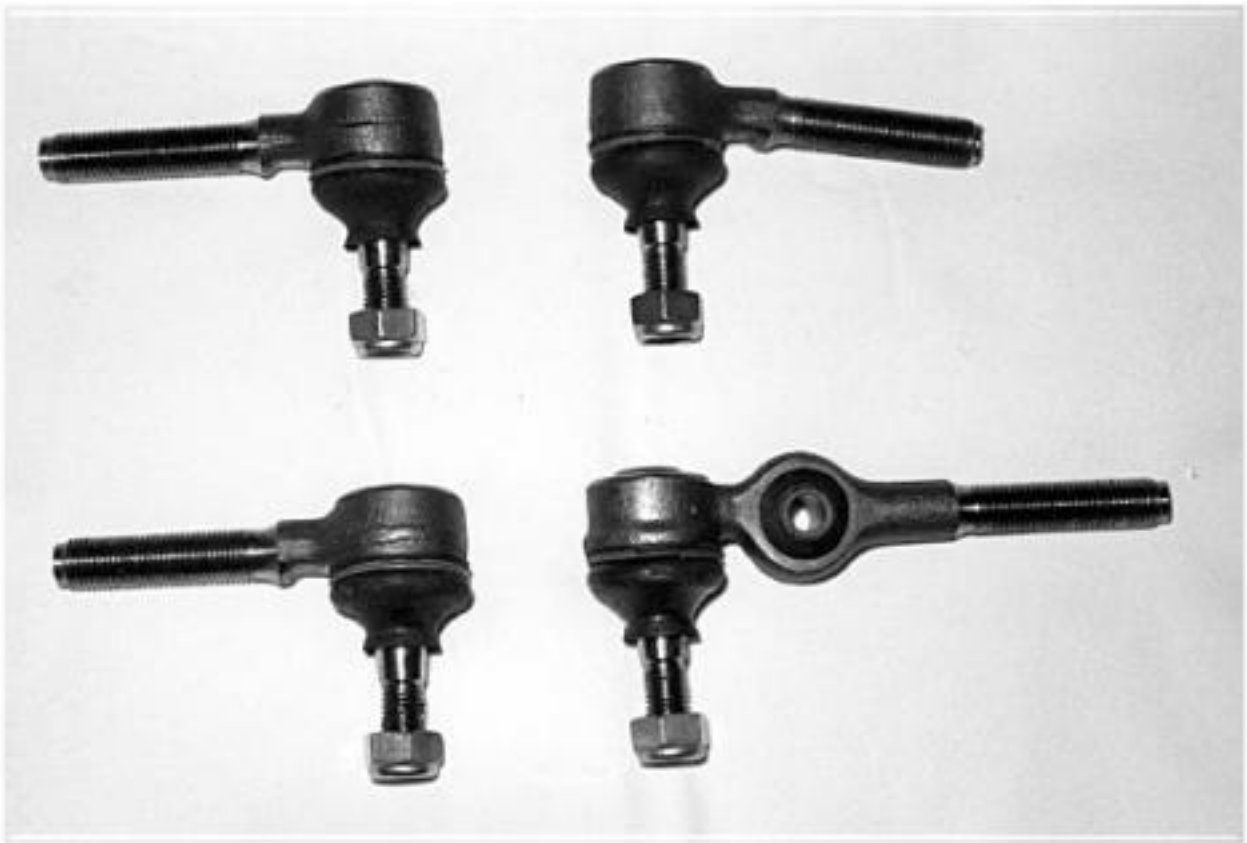
to the steering arm. Instead of the intended straight-line movement, the track-rod ends follow an arc while operating at their altered angle and pull the steering arms closer towards the centre line of the car. This is particularly noticeable as the track-rods sit behind the wheel centre-line on the Beetle suspension. The result is toe-out, which is detrimental to the steering geometry, and ultimately gives poor handling. The greater the lowering of the suspension, the greater the upward inclination of the track-rods and the adoption of an unnaturally acute angle where they mount, and the greater the change in suspension geometry as the suspension is compressed. On anything but the smoothest roads, the steering will be deflected by bumps, and the car will become difficult to keep in a straight line.

This 'bump steer' will make the car uncomfortable to drive, as the movement is transmitted through the steering column to the steering wheel. The other problem is that, in lowering the car, the track-rod will become uncomfortably close to the bottom of the petrol tank, and may even rub on it, which is, of course, a safety hazard. The solution to these problems is to relocate the outer track-rod ends to a position below the steering arms rather than above. As the steering arms have tapered holes to accept the track-rod ends, these must be drilled out or reamed to accept special bushes (available from aftermarket parts suppliers) which have tapers the other way around and thus allow the required fitting. This solution places the track-rod ends some 66mm lower than before, and closer to their pre-lowered angle.

With a new bush fitted to the steering arm, it's ready to accept the track-rod end pin into the tapered eye.

Track-rod end sizes differ depending on year of manufacture. Use the chassis number to order the correct replacements for your Beetle. (Courtesy Neil Birkitt)

Replacement track rods are available to substitute for bent items. These can be strengthened with a metal sleeve, welded on the outside, but this must not interfere with the adjustment of the ends.



A set of new track-rod ends showing the differences in design. These must be fitted correctly to the Beetle during replacement.

The stub-axle is best taken to a reputable engineering shop for them to drill or ream the steering arm eye out to 17mm. If you decide to do this at home, use an accurate pillar drill and clamp everything in place. Put a piece of wood underneath the arm, ensuring it is absolutely parallel to the flat face of the arm, otherwise the hole will be off centre. Apply drill pressure evenly and work at a slow speed using plenty of cutting compound to assist the process. If you back the drill off every so often, it will allow swarf to clear. Once through, release the arm from the workbench and de-burr the hole. Carefully file each side of the flat facing-surfaces of the arm. Trial-fit the new bush, and obviously ensure that the taper fits in the correct way to allow the track-rod end to mount from underneath the steering arm. The bushes are an interference fit and can only be accurately located with a press, but be prepared to make some fine adjustment with a file to chamfer the edges to get the correct fit.

The track-rod ends will then fit into the new bushes from beneath the steering arm.

Like all moving parts, track-rod ends are subject to wear and will eventually need replacing, so this is a good point to do so. Early track-rod ends are easily identified by the presence of grease nipples requiring regular lubrication at 6000 mile intervals. All 1967 and earlier Beetles use smaller (12mm) OD ends, whilst those from chassis no. 118 857 240 (May 1968) had larger (14mm) OD maintenance-free ends which were packed with grease and sealed at the factory. All aftermarket ends are of this style, to prevent lack of lubrication and premature failure, but the threads of the different type of ends are either M10x1 or M12x1.5, so ensure you get the correct replacement parts.

The track-rods themselves come in two lengths, the shorter one being on the right on RHD Beetles. The longer, left-hand rod provides the mount for the steering damper in the special fitted end. The track-rods themselves should always be checked for straightness, and replaced if bent. Aftermarket stock and strengthened rods are available for both sides. If the original rods are serviceable, you can strengthen these by slipping a piece of 0.050in/1.27mm wall-tubing over the rods, making sure that it won't interfere with the track-rod ends or pinch bolts. The tube can then be drilled in a couple of places and welded through the holes. This will prevent any possibility of bent track-rods in the future, which can knock the steering geometry out if a bend occurs.

Before loosening the pinch bolts and unscrewing track-rod ends from their location in the rods, however, the position must be marked first. Use typists' correction fluid to mark the position of the track-rod end relative to the pinch bolt and mark the inboard and outboard ends of the rod. When unscrewing the old track-rod end,

count the number of turns required to remove it. This way, the new end can be fitted to match the marks and thus retain the correct geometry when the rods are refitted. Note also that the short track-rod has an angled joint at its inboard end, which must not be used elsewhere.

With all four track-rod ends replaced, install the rods to the joints with the left-hand threads on the left-hand side of the car and the correct ends affixed to the steering box drop-arm. At the end of your suspension assembly, remember to have the tracking adjusted by a garage or tyre-shop with the correct equipment. The Beetle's front wheels should toe-in slightly when stationary. When moving, the rolling resistance will take up the play in the steering gear and suspension and bring the wheels parallel. Only when cornering should the wheels toe-out.

Adjustment of the track-rods is made by backing-off the pinch bolts and rotating each of the rods an equal number of turns in the same direction.

If you are fitting dropped disc brake spindles to the king and linkpin front suspension, they must now be located via the linkpins to the trailing-arms and bolted up, once the correct shims have been installed. With the track-rods fitted, and the new disc brake components installed (including calipers, discs, bearings, seals and flexible brake pipes) the whole front end must be realigned or you could end up with a low, but ill-handling Beetle. There are many different options on the actual discs which are applicable to both early and late front suspensions, and the section on the ball-joint front suspension should be referred to when deciding on options for your car.

CUSTOM AND SPEED PARTS DISC BRAKE

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Aftermarket eccentric camber bushes allow greater negative camber at the stub-axle due to the fact that the tapered hole for the ball-joint pin is drilled further offset than stock.

An ideal performance setup: CB Performance dropped spindles for disc brakes, bump-steer bushings, eccentric camber bushes and long-travel ball-joints. Just add a Beetle!

DISMANTLING BALL-JOINT SUSPENSION AND OVERHAULING BRAKES

In order to fit an adjustable bush, change the ball-joints, or change to the better disc brake setup, you will first need to do some disassembly work. As with work on the linkpin model Beetles, loosen the wheel nuts then jack-up and secure the front of the vehicle on proper axle stands. Ensure the handbrake is on, to prevent the possibility of the car rolling backwards. With the wheels

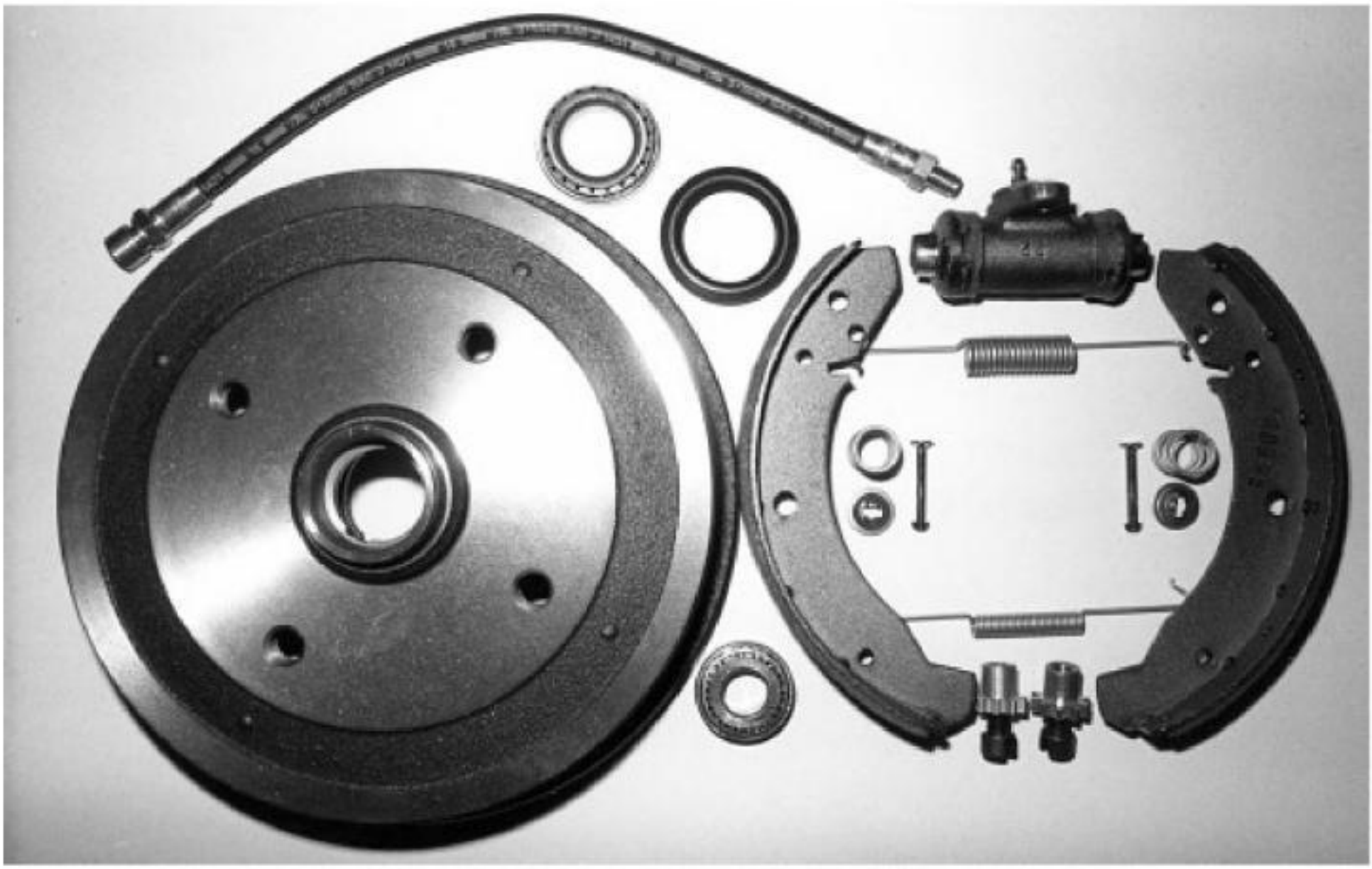
removed, the dust covers on the drum brakes can be prised off. On the nearside cover, the circlip that retains the speedometer drive also has to be removed, and the cable withdrawn from the back of the stub-axle before the cover can be removed. Using an Allen key, undo the spindle clamp under the cap and unscrew it with a spanner (remember, the left-hand or speedometer side has a left-hand thread and vice versa). Remove the tongued thrust washer and outer bearing. The brake shoes will have to be adjusted through the brake backplate (on all 1967-on Beetles) or through the drum itself (on 1966 year only Beetles) to withdraw them away from the friction surface. The drum can now be withdrawn from the stub-axle.

Attached to the brake backplate are the brake shoes and the brake cylinder, plus the return springs. The springs – which draw the brake shoes away from the drums when brake pressure is relieved - can carefully be removed with pliers. In the centre of each shoe is a retaining pin, held in position by a spring-loaded slotted cup-washer, which must be removed. With pliers or, ideally, a special brake tool, press down on the washer whilst simultaneously turning it to release the slotted head from the cup. The shoe can then be withdrawn from the brake adjuster and the brake cylinder.

If only a simple brake overhaul is required, the brake shoes, and drum (complete with new bearings fitted), could simply be renewed at this point, and the disassembly process reversed. The brake cylinder could also be changed. To do this requires the removal of the flexible brake hose and undoing the retaining bolt. The brake system would then require bleeding to remove air, once rebuilt.

To change to the superior disc brake assembly, the brake backplate must be removed from the stub-axle, once the brake hose is undone, by removing the three retaining bolts. Using a

releasing fluid will help ease the process, as they will probably never have been undone since the car was built. The stub-axle is then accessible, and the two large ball-joints, together with the track-rod ball-joint are now visible.



A simple rebuild of the stock brakes also improves performance, and retains originality. New drums, wheel cylinders, brake shoes, retainer pins and springs, 'star' brake adjusters, bearings, seals and flexible brake hoses are all available.

Removing the retaining nuts from all three is relatively straightforward, with releasing fluid again proving helpful, but actual separation of the ball-joint pins from the tapered retaining eyes

within the stub-axle and steering arm is more problematic. Never hammer on the end of the ball pin thread, but use a proper ball-joint separator. A 'pickle-fork' tool may have to be used if the joint is stubborn, as this provides greater leverage between the two parts. This has the disadvantage of possible damage to the rubber seals, but this is only of concern if the joints are not being renewed. Once free from the tapered retaining eye, the top trailing-arm then has to be levered upwards to release the stub-axle from the ball pin threads. The eccentric bush may well remain in place on the top ball-joint pin, and this must be pressed off with an hydraulic press.

To replace the ball-joints, the front anti-roll bar, the shock absorbers and the trailing-arms will all have to be removed from the front suspension assembly. The reason for this is that the ball-joints are pressed into the eyes of the torsion-arms, and are knurled to ensure a tight press fit. It is impossible to replace them without an hydraulic press.

Front shock absorbers

Starting with the front shock absorbers, the upper pin mounting locates through a horizontal plate in the tower of the front beam assembly, and the top hexagon nut should be undone. If the whole piston rod turns, the hexagon on the buffer stud itself must be held with an open-ended spanner. Alternatively, the piston rod must be unscrewed from the buffer stud. With the bottom nut undone, the whole unit can be detached from the beam. The trailing-arms can be slid off the leaves in the torsion-tubes once the hexagon securing nuts and Allen-headed grub-screws are removed. All dirt must be cleaned out of the hexagon-headed end before releasing with the Allen key, or it will not locate properly and will round off the internal faces. The trailing-arms are then free to be removed, and

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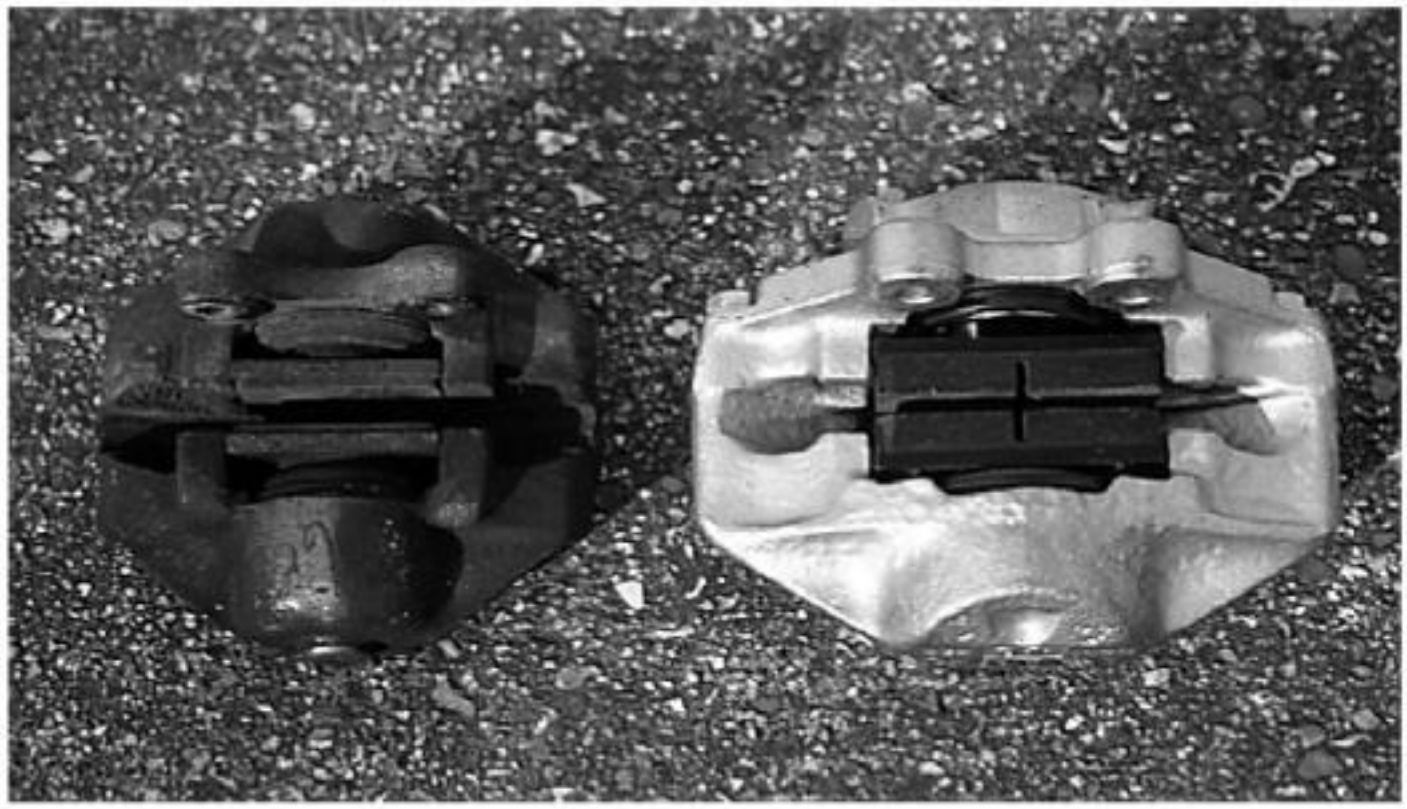
with 48mm pistons. The spacing and size of the bolt holes that attach the caliper to the stub-axle are exactly the same as the Beetle units. The Talbot calipers are physically larger units than the Beetle originals, due to the increased size of the pistons, and sit slightly offset to one side of the disc itself. This latter problem can easily be corrected by the addition of thin M10x25mm washers between the caliper mount and the stub-axle itself. The disc brake backplate will need to be trimmed to fit around the larger size of the Talbot caliper, unless the plates are to be dispensed with. However, they are there to serve a purpose, keeping dirt away from the discs, so it is worthwhile using them with this minor modification.

The flexible brake hose is attached to the Talbot unit from a vertical position, rather than a horizontal position into the side of the caliper, as the case with the Beetle. The standard flexible brake hoses could be overstretched, and it is worth making the change to the stainless steel braided brake lines available from companies such as Aeroquipe or Goodridge, made to an appropriate length to give the necessary slack. Pedal travel is increased slightly with the Talbot conversion due to the larger brake pistons, but it is perfectly acceptable. The conversion can also be used to upgrade the braking power of the disc-braked 1302S and 1303S model Beetles. If nonstandard Beetle discs are used, then the diameter should be carefully checked for clearance. Using the 1971-on VW Type 3 or 1969-1972 VW Type 4 discs, for instance, increases the disc thickness to 11mm, but would foul the Talbot caliper due to their 281mm diameter. Only by machining the discs down to the Beetle diameter, could these still be used.

Calipers from the British 1981-1985 model Talbot Horizon will fit the Beetle stub-axle, and have 48mm pistons for increased stopping power. (Courtesy Neil Birkitt)



The Talbot Horizon caliper is much larger than the equivalent Beetle unit, as can be seen here. Parts can be bought brand new, or sourced from breaker's yards. (Courtesy Neil Birkitt)

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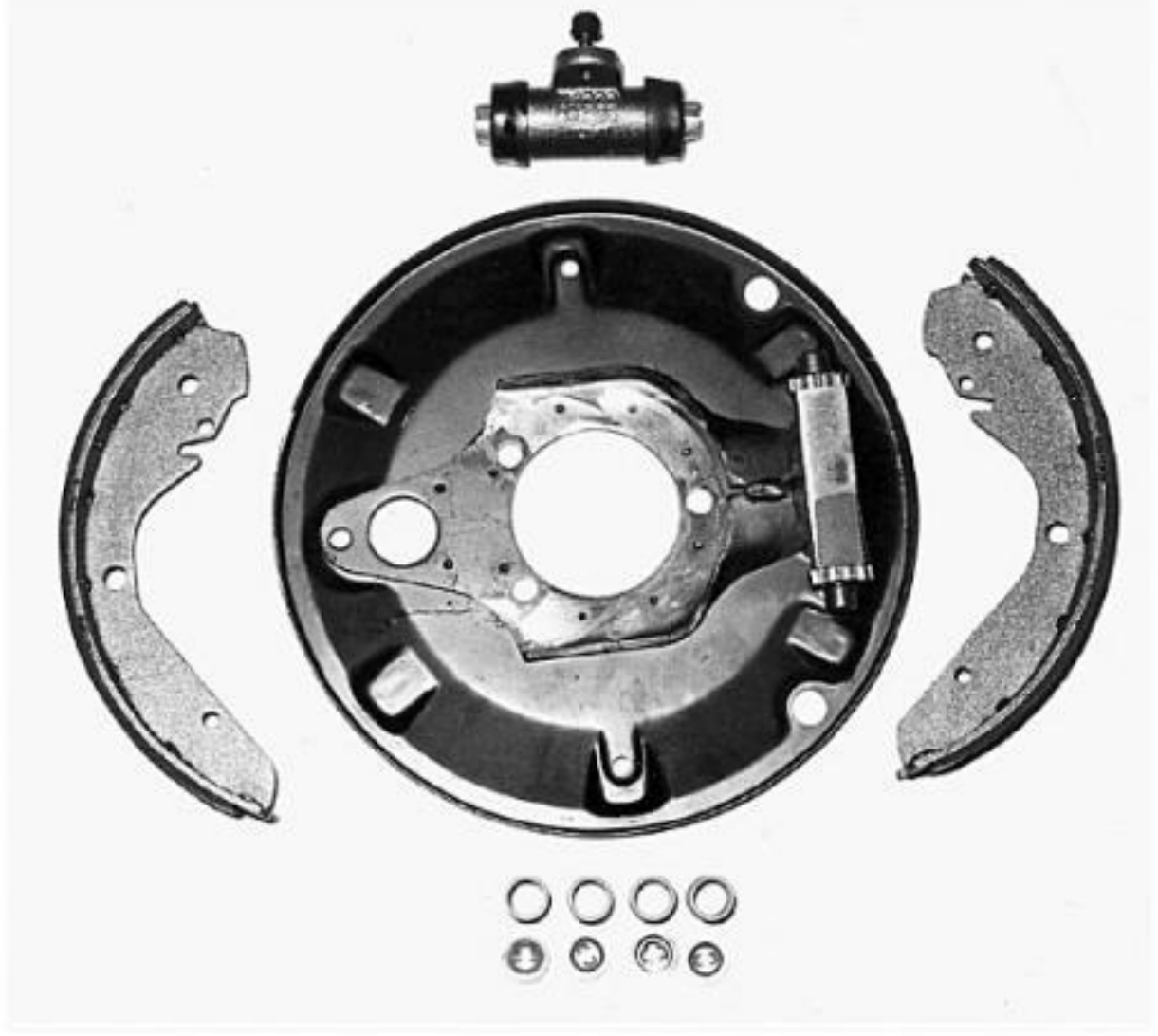
1966 or later Beetle next to that of the 1302/03, you will see that the former has a three-bolt mounting to the stub-axle, whereas the latter has a four-bolt mounting. The later unit has to be modified to replicate the mounting system of the earlier type of backplate. Again, it is recommended that this is undertaken by a reputable engineering shop, as the measurements are critical when dealing with the car's braking system.

Early five-bolt Type 3 drums can be adapted to the later ball-joint Beetle suspension to give a period look, and better braking. You'll need modified 1302 or 1303 Beetle brake backplates and stock internals however.

On the original, early, backplate, use vernier calipers to measure the bolt hole sizes and the distance of each from the hole for the

stub-axle. Cut a small, thin piece of sheet metal and place it over the holes on the old three-bolt backplate. Turn the backplate over and scribe through the holes onto the piece of sheet metal, before using a centre punch to mark the holes prior to drilling. Carefully drill the three-bolt holes in the sheet metal, and de-burr all the edges. After drilling a small lead-in hole in the centre of the plate, use a small jigsaw to roughly cut the hole for the stub-axle. Bolt the steel pattern to the old backplpate, and carefully file the hole for the stub-axle to size.

Moving to the new or replacement backplate, grind off the paint around the four bolt-holes, front and back, and weld up the four holes (another good reason to go to a specialist engineering shop). Both sides of the backplate will need to be welded, ensuring the welds are good and solid. Mark the centre line of the brake cylinder location hole across the backplate, which helps locate the bolt-hole pattern. With the pattern located, mark and centre punch the bolt-holes. Pilot drill, then drill the holes out to the correct size. Once the backplate is deburred and flattened off, it can be painted ready for fitting to the original Beetle stub-axles. New 1302/03 brake shoes, wheel cylinders and adjusters can then be fitted prior to the addition of the Type 3 five-bolt drums.



Modified backplate, larger 1302/03 wheel cylinder, and new brake shoes, springs and adjusters complete the retro-look brake upgrade.

RAISING OR LOWERING BALL-JOINT FRONT SUSPENSION

I've mentioned the use of adjusters to raise or lower the Beetle front suspension, so now let's see what is actually involved in fitting them. As we've seen before, the Beetle front suspension consists of the two stacks of flat torsion-bars (or springs) positioned within the two parallel tubes running horizontally and bolted to the front of the chassis. The torsion 'effect' of this type of front suspension comes into play when the trailing-arms, fitted onto the ends of the torsion-leaves, are forced upwards, thereby placing a load on the torsion-bars themselves. The bars, being made of torsional steel, resist the

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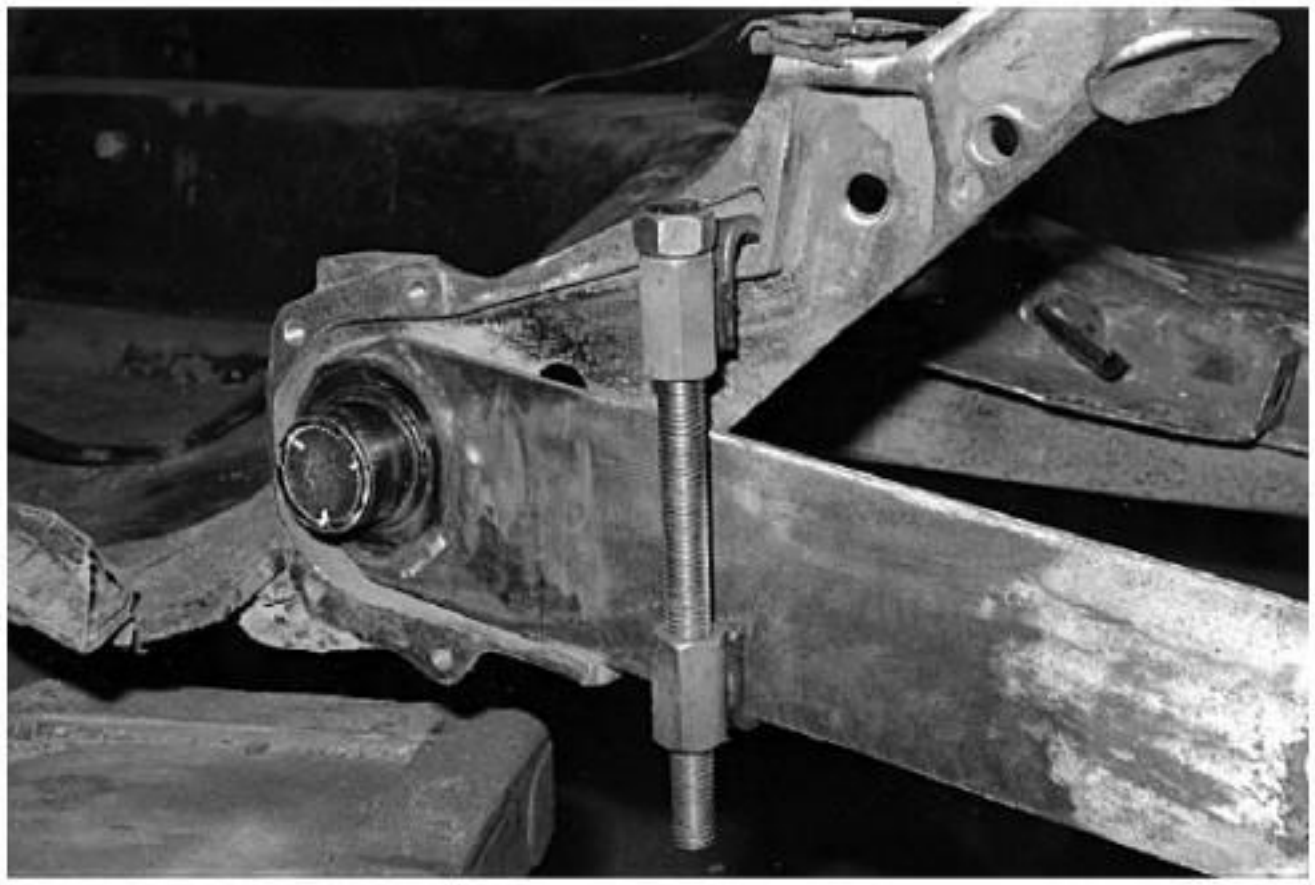

Spring compressors, or a trolley jack, can be used to lift the spring-plate from the step, before lowering it in a controlled and safe way.

Make sure that your hands are clear of the plate when it is released from its resting place on the step. It is possible to knock the plate off the step with a soft-faced hammer, and then to lever the plate from the torsion-bar with opposed screwdrivers. However, the problem with this seemingly simple method is that the downward force may well dislodge the inner splines of the torsion-bar, leaving you with no exact reference for reassembly.

Preferable methods are to either use a trolley jack to lift the plate up and off the step (with a chain running under the jack and over the torsion-bar housing to hold the car on its supports), or spring compressors, which lift the arm from the step before lowering it in a safe and controlled way. From here on it is just a case of sliding the spring-plate from the torsion-bar without dislodging the inner end, and refitting it plus or minus the desired number of splines. It is also

The torsion-bar is splined on each end to provide fine adjustment of the rear suspension. Bars are marked for left or right-hand side use, and should not be exchanged.

New torsion-bar end covers can be fitted as well as replacement urethane bushes. The cover is fitted by using longer bolts to pull the cap on, before replacing them with the originals.

Rubber bump-stop bushes can also be swapped for longer-

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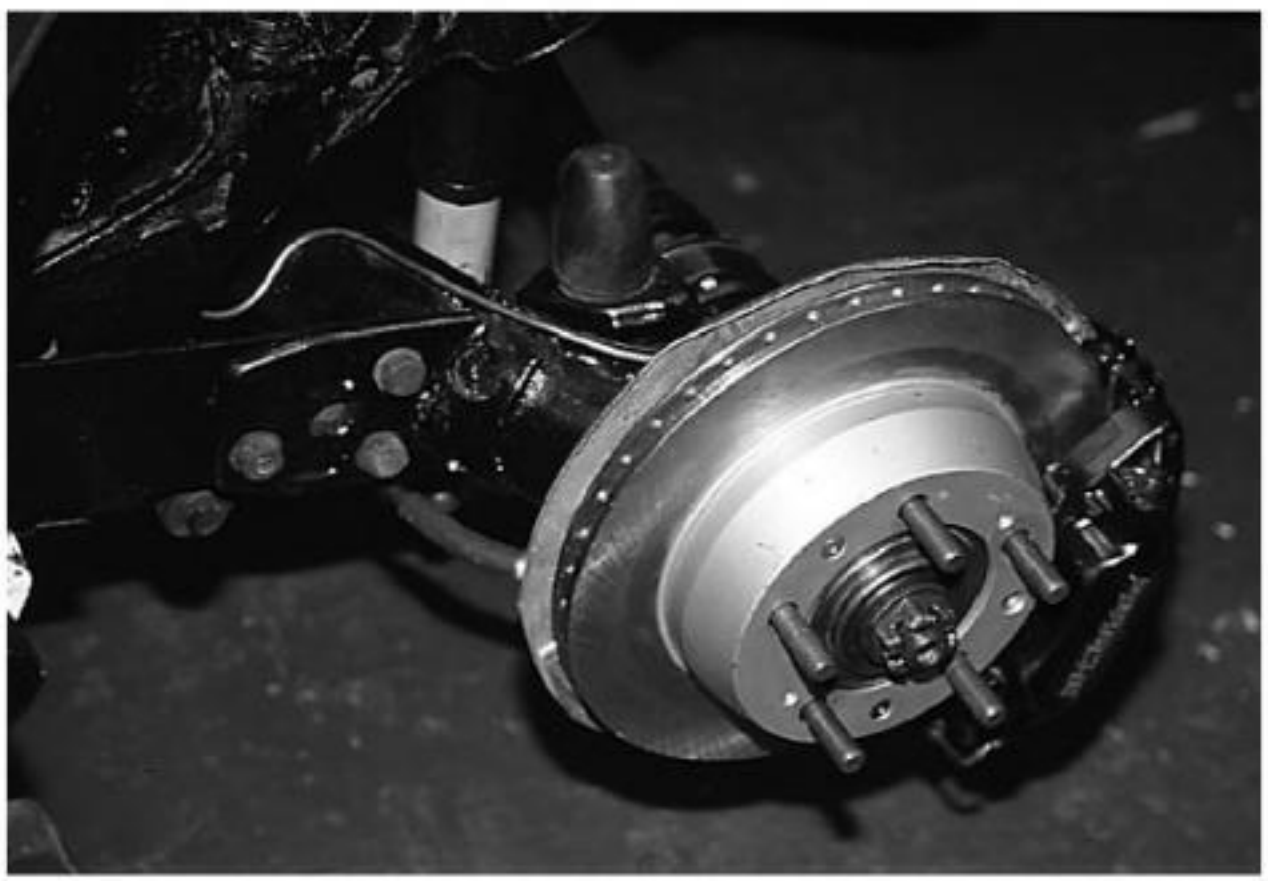
A high performance Beetle, with IRS rear suspension and the Kerscher rear disc brake conversion, fitted with VW Corrado calipers. Bilstein shock absorbers, a 19mm Kerscher rear sway bar and Kunifer and steel brake lines are all excellent performance options. (Courtesy Mike Key)

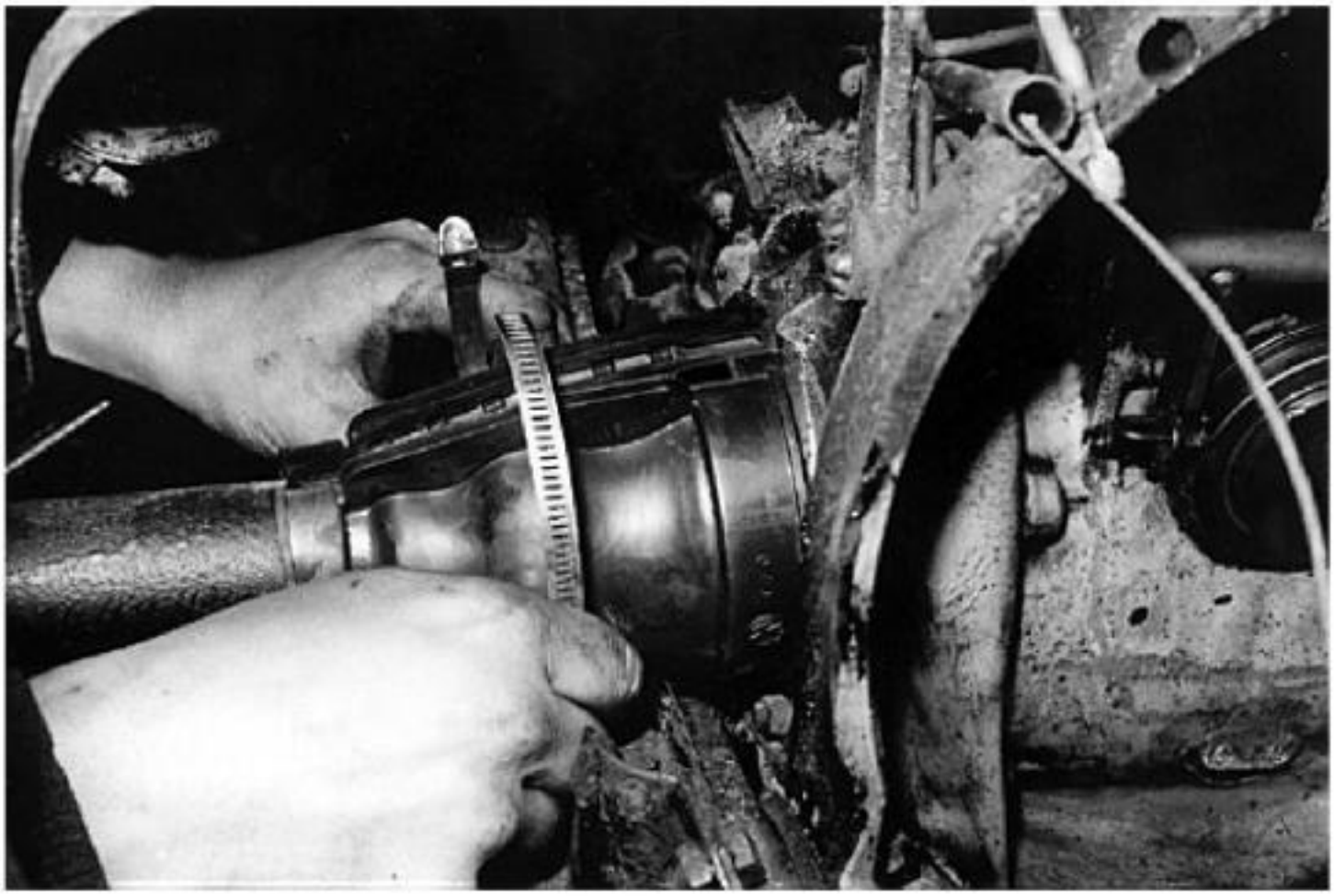


ends of the shafts supported in ball bearings in the rear hub assemblies. The inner ends of the shafts are flattened into 'spades' to match the fulcrum plates mounted in slots in the gearbox differential side gears. These inner ends move freely in spherical housings, which form ball-joints centring on the axle shaft universal joints. Rubber gaiters (or dust sleeves) are wrapped around the inner ends of the tubes to protect against dirt and to prevent oil spillage. You can always tell if a car still has the original gaiters because they are one-piece sleeves, clamped and sealed at either end with suitably sized worm-drive (jubilee) clips. The gaiters nearly always split or crack with age and use, and consequently leak gearbox oil. This is bad news for the gearbox as it is gradually losing its oil, and the oil is unsightly on the axle tubes as it runs down towards the hubs.

These one-piece sleeves cannot be renewed without removing the bearing housing at the outer end of the axle tube. This is affixed to the outer end of the axle tube with a pressed dowel pin, and is a major operation to remove and replace successfully. To avoid this, replacement gaiters are made as 'split' items for easy fitting. In other words, the gaiter wraps around the axle tube and is held together by small nuts and bolts. Gaiters are available in normal black rubber, or high-grade copolymer which is not only stronger, but available in different colours.

In order to replace the old gaiters, set the back end of the car up on axle stands once the wheel nuts are loosened, preferably trying to keep the axle tubes as level as possible. If they swing into positive camber it tends to make the job harder, as the gaiter becomes trapped between the axle shaft and the frame fork. Remove the rear wheels for better access, and place a drip tray under the side you are working on since there will almost certainly

be half a pint of old oil trapped inside which will otherwise spill everywhere.



The new gaiter is wrapped around the axle tube and held in place with a row of small nuts and bolts on the top edge. The metal clips at either end can be replaced by stainless steel items.

Remove or cut off the old worm-drive clip and cut away the old gaiter. Clean the axle tube and use a little jointing compound on the mating faces of the new split sleeve. A silicone sealant such as that used for aquaria is an ideal type of compound for this job. Ensure that the split in the sleeve is faced slightly back from horizontal at the top edge. This prevents the sleeve from trying to open when the suspension is compressed, which could cause oil leaks.

With the sleeve carefully positioned around the axle tube and retaining plate on the gearbox, put the small bolts and washers

through the relevant holes and fasten the corresponding nuts loosely. Do not finish tightening these until the axle is in a loaded condition with the vehicle on the ground. It is possible that the gaiter may need some adjustment if it becomes strained or twisted before fitting the new clamps. Don't overtighten the clamps or screws; the sealant should ensure that the gaiter remains oil-tight.

Transmission oil

Check that the transmission is topped up with SAE 90 hypoid oil to replace any that has been lost. The filler plug is located on the side of the gearbox and requires a large hex-headed key to undo it. As a routine, gear oil should be checked every 6000 miles and changed at 30,000 mile intervals. The Beetle gearbox holds just under four pints unless it is newly rebuilt, in which case an extra half-pint is required. When refilling a VW gearbox, put the car up on axle stands first, and then wipe the drain plug and filler plug clean with a rag. Make sure you have a container ready before you remove the bottom drain plug!

Always remove the filler plug before undoing the drain plug – not only does it ease draining by allowing the ingress of air, but it also avoids the possible situation whereby you drain the oil only to find that the filler plug has seized in place! When refilling, it is often easier to jack the left side of the car up by itself so that it is at an angle. That way it is simpler to get all the oil in from the plastic bottle the oil normally comes in.

INDEPENDENT REAR SUSPENSION

Beetles from 1968 onwards began to utilise a different type of rear suspension, called Independent Rear Suspension (IRS), which first appeared on the Automatic Stick Shift models in the US market,

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runs transversely under the torsion-bar tubes.

TYRE CLEARANCE

Before we leave the Beetle IRS rear suspension, there is a final modification that is of interest to those building a dune buggy. If large rear tyres are used, there is potentially a problem of tyre clearance on the torsion-bar housings. On an IRS Beetle, these are the longer length 269/16in bars that provide the later Beetles with a softer handling. However, like the earliest Beetles that also used longer torsion-bars, they stick out from the spring-plate retaining cover by several inches.

The solution is to exchange the bars with those of a swing-axle Beetle, which are shorter at 213/4in. To enable them to locate to the diagonal A-arm of the IRS Beetle, the swing-axle spring-plate will also be required. Since this is longer, it will have to be shortened and shaped at the end that attaches to the diagonal A-arm. It will also have to have the elongated mounting slots to allow toe-in adjustment drilled through them. This is a job for a qualified machine shop, and should not be done if the measurements will be less than 100% accurate. As the plates are to be used on a buggy, you may also wish to use aftermarket plates designed for heavy-duty off-road use, and there are many to choose from, including the US-made Summers Brothers plates. Again, these will need to be bought as spring-plates for the swing-axle Beetle and modified to suit this particular application.

OBTAINING PARTS

The Beetle design allows for a huge diversity of parts interchangeability and modification as we have already seen. In all cases, the emphasis should be on thinking through the type of

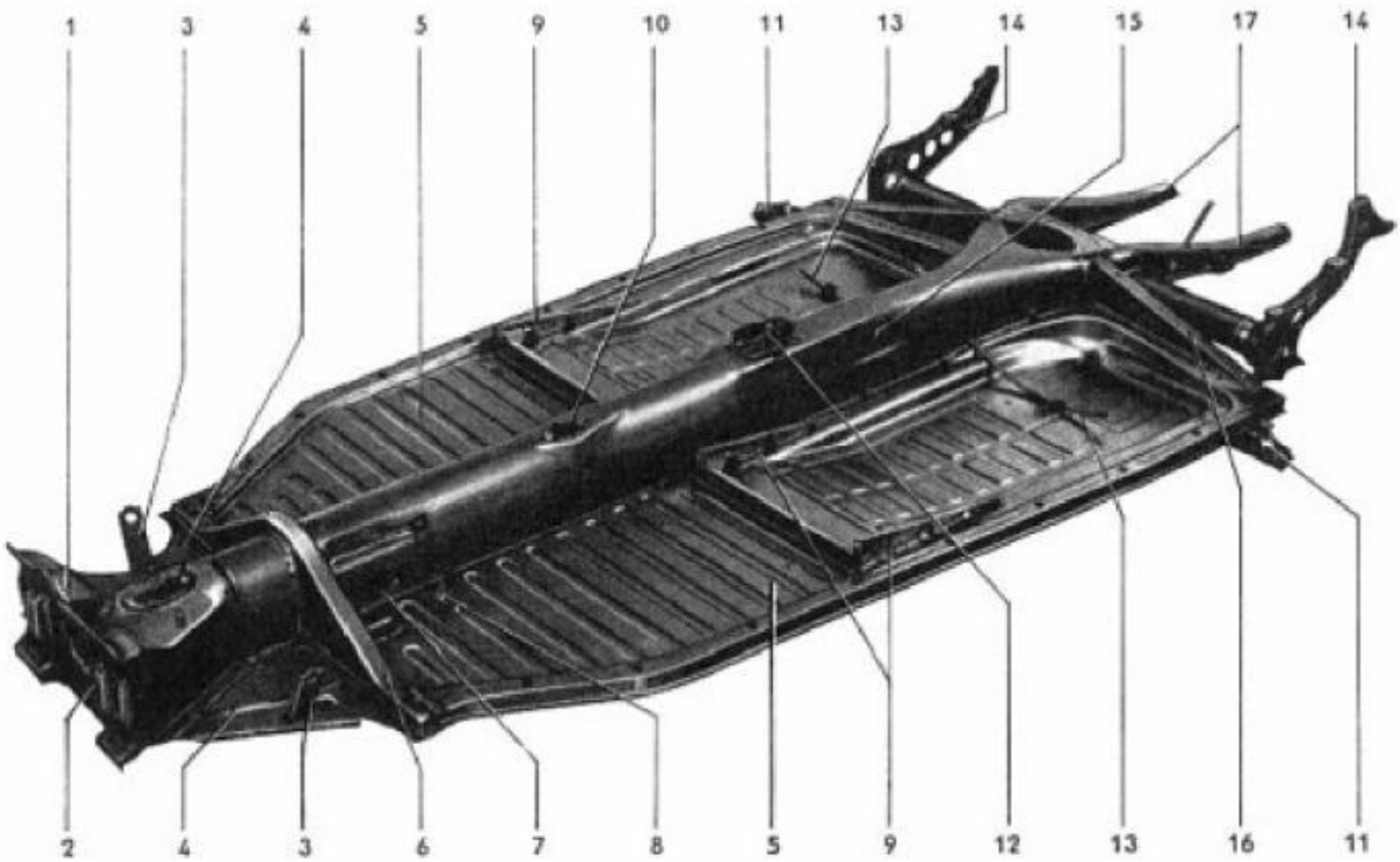
changes you will want to make before actually starting anything. Firstly, this is simply good planning, since it ensures you do not have to tackle a major job twice, and you can plan a series of jobs that have the same basic starting point. The second issue is simply the question of time and money. You can save a lot of time by locating parts from dealers (or even secondhand from specialist breakers) in one operation, rather than returning time and time again. You may also be able to secure a better price for yourself by doing things this way. However, if only one job is to be tackled at a time, then parts can be purchased in a logical step-by-step way to spread the cost.

Shop around for the best prices with dealers, and also check the small ads sections of enthusiasts' magazines. You may well be able to find the parts that you are looking for at greatly discounted prices.

Finally, with the thriving show scene for the air-cooled VW enthusiast, go to as many events as possible and check out the bargains on new and secondhand parts at the swapmeet section.

Chapter 4
The chassis

The Beetle chassis/floorpan is the foundation for the rest of the car, as it provides the mounting for the suspensions, gearbox and engine, and the bodyshell. Complete with suspensions, wheels and tyres, the floorpan forms an independent rolling chassis, consisting of a central backbone, 140mm wide and 165mm high, which provides much of the strength for the assembled car when the body is mounted to it. The front frame-head widens to accept the four mounting bolts for the front axle assembly, steering and brakes, and the U-shaped fork at the rear supports the transmission and drive shafts. The engine bolts to the bellhousing of the gearbox, but is otherwise unsupported. Welded on either side of the central backbone are the floor pans which carry the runners for the seats, the mounting for the battery, and the support for the pedal assembly.



1 - Frame head — upper part
2 - Frame head — front plate
3 - Brake hose retainer
4 - Frame head — lower part
5 - Floor plate
6 - Front cross member
7 - Hole for pedal cluster
8 - Accelerator pedal attachment
9 - Seat runners
10 - Hole for gear lever
11 - Jack sockets
12 - Hand brake lever and heater control mounting bracket
13 - Guide tube for rear foot level heating control cable
14 - Spring plate supports
15 - Safety belt attachments
16 - Frame end plate
17 - Frame fork

The VW Beetle chassis – the foundation for the rest of the car. (Courtesy Walter Bach)

The very simplicity of the chassis design makes it an ideal candidate for re-bodying with bodyshells of different designs, such as kit-cars or dune buggies. It also means that a restorer can physically remove the Beetle bodyshell from the chassis to allow unrivalled access to both parts before reassembly. Whether the body is to be restored or discarded to allow kit construction, the

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metal. Equally, the side channels of the floorpans may have been damaged during the removal of the old body if a poor welding repair to the heater channels of the Beetle body physically joined the body to the floor. Sadly, this is a common problem, and only grinding or a cold chisel can then part the two. It is always better to retain the original pans if they are serviceable, as the original metal – particularly on pre-1966 Beetles - is much thicker and of a better quality than most 'pattern' floorpans available.

Nevertheless, floorpans, or even just sections of floorpans, can be purchased quite readily and fitted quite easily. They can also be fitted to a complete Beetle where disassembly is not being undertaken, though the work required to position them is greater with the body still in place. If only the battery section has rotted, judicious shortening of the chassis may remove most of the bad metal anyway, so bear this in mind. If a full-length floorpan is to be fitted, this must be done prior to shortening the whole chassis to prevent any misalignment problems. If original VAG panels are obtainable, they are a safer bet, in terms of quality and fit, but obviously will be more expensive. Ensure that you have the correct panels for your year of chassis, and that they are set up for the driving position in your car – the driver's side will need the additional support for the accelerator pedal.

Begin removing the old panel by chiselling along the old floor panel next to the tunnel. The floor must also be released from the front and rear cross-members before it can be removed. The remaining strips of floor, still attached by spot welds to the tunnel flange, can then be carefully chiselled off and the flange dressed and cleaned up ready to accept the new floorpan. Once offered up into position, the floorpan will have to be plug-welded into position on the central tunnel flange, replacing the original spot-welds. This

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Front stiffeners fitted to the front suspension of a high performance Beetle. (Courtesy Mike Key)

Before disassembling the parts from the IRS donor chassis, make sure that the position of the spring-plates relative to the A-arms is marked with a single scribe mark, as these parts will need to go back together in perfect alignment once transplanted onto the earlier chassis. The bolts which hold the spring-plates to the A-arms can then be removed. The A-arms themselves are released from the donor chassis by undoing the large Allen bolt which pivots the arm at the inner end, with a large Allen key or gearbox drain plug wrench. The A-arms can then be removed together with the shock absorbers. Take off the torsion-bar end cover and carefully pull the

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together top and bottom, using seam welds for strength. All the welds should have a coat of seam sealer brushed on to them before finally painting the panel to provide some weather protection.

BEETLE CABLES AND PEDAL ASSEMBLIES

With many Beetles that are still on the road being nearly 30 years old (and some more than that), it's inevitable that parts wear out and things break. Whilst the chassis of your Beetle is receiving an overhaul with the more glamorous parts, such as disc brakes and suspension adjusters, it is worth checking and replacing the operating cables that run within conduits through the central tunnel.

Accelerator cables

Starting with the accelerator, there really couldn't be an easier cable to change on the Beetle than this. At the engine end, the cable attaches to a small clamp screw or nut on the carburettor lever. This is easily undone with a screwdriver or ring spanner (depending on the year). The cable travels through the centre tunnel in its conduit and exits at the pedal end with one of two arrangements: either an eye on the end of the cable which is attached to the accelerator lever by a clevis pin and split pin, or a shaped endpiece which locates directly into the accelerator lever.

On right-hand-drive cars, the accelerator lever itself is hidden behind a side cover bolted to the tunnel which is located under a metal foot-plate beneath the front floor-mat. On left-hand-drive cars, the cable can easily be seen where it attaches to the accelerator pedal. The cable is therefore simply pulled out at the front end and a new (well-greased) cable replaces it, being routed through the conduit in the tunnel to the rear of the chassis. A smaller metal conduit passes through the engine fan-housing to


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